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THE UNION SWITCH & SIGNAL COMPANY

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/N o t e/ -- All pictures in this report taken by The Union Switch & Signal Company, except photograph of 40-lb. H. E. Bomb Body and photograph of ten parts for 105 MM. Howitzer, M 2 A1. These two photographs taken by, and used through courtesy of, the Westinghouse Air Brake Company, Wilmerding, Pa.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

WAR MATERIEL PRODUCTION BY

THE UNION SWITCH & SIGNAL COMPANY

--o--

(1 9 4 0 - 1 9 4 5)

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

Through utilization of engineering and production skills, the maintenance of 'round-the-clock schedules, and making full use of available manufacturing space, existing machinery and the services of skilled personnel, The Union Switch & Signal Company made a not inconsiderable contribution to the war effort of the United States, and other members of the United Nations in the years from early 1940 through mid-1945.

A total of more than 43,500,000 items of war materiel -- ranging from bomb bodies and shells, to parts for airplane propellers, devices permitting the radio control of aerial bombs, .45 caliber automatic pistols, and essential parts for airplane detection devices -- was produced by the Company during that time. In addition there was produced -- through subcontracts to other companies, or through furnishing forgings and other pieces -- more than a quarter-million additional items directly entering into the war production program of the nation.

All this volume of production was achieved by the Company over and above an increased output of its regular line of important railroad equipment -- items which materially aided the nation's railroads in the performance of the greatest task in their history.

- - -

During these war years -- 1940 through mid-1945 -- special war materiel to the value of (*)_____ and equally important railroad equipment to the value of (*)_____ _____ was produced and delivered by The Union Switch & Signal Company.

- - -

With the outbreak of the war and the placing of contracts for production of war materiel, The Union Switch & Signal Company was turned to for several reasons, among them:-

1) The Company was known to have the available manufacturing space -- (existing structures contained over a million square feet of floor area) -- and would require no new buildings to participate in any program of war production.

2) It had the trained personnel with which to produce war materiel, and also have much machinery that could be utilized.

3) It had participated in various projects conducted by the United States Ordnance Department since World War I.

4) It had met production schedules on its contracts in World War I.

- - -

(*) These figures to be filled in by the Company

With the taking on of war contracts -- in addition to increasing its output of equally important railroad equipment -- the management of the Company, its engineers, supervisors and the men and women of its production lines, accepted a challenge to quadruple pre-war output within the existing plant. This challenge was met by increasing personnel from the immediate pre-war average of 1,800 employes, to a war-time peak of more than 6,350 men and women workers; by the institution of three shifts, working seven days a week; by the re-location of departments in the interest of conserving space, and by making use of the engineering, research and production facilities of the Company to the fullest extent.

- - -

So successfully was this challenge met that during a visit to the Company's plant at Swissvale, Pa., in 1942, Lieutenant General William S. Knudsen voiced this tribute to the Company's resourcefulness:-

"What I like about you fellows is that you took your old plant and made a REAL manufacturing institution out of it."

- - -

The Pittsburgh Ordnance District, the United States Navy, the Army Air Forces, the United States Treasury Department and the British Purchasing Commission -- as well as many manufacturing plants that had converted to war production -- turned to The Union Switch & Signal Company for materiel for the reasons enumerated on Page III.

- - -

The Company's cooperation with the United States Ordnance Department went back to World War I, when the Company also was a major producer of armaments. During 1915-1917, the Company delivered $4,160,173.79 worth of such munitions as 4-inch and 4.5-inch shells; 18-pound shrapnel, and rifle parts.

In 1918 and 1919 the Company also manufactured aircraft products to the value of $13,479,762.42. These included 2,500 LeRhone 80-h.p. engines, special forgings and spare parts. The aviation industry was in its infancy at the time and the Company achieved distinction when it completed its 2,500 airplane engines on schedule. In addition, Georges Guillot, an engineer for the Gnome-LeRhone factories in France, who was stationed at the Company's plant for a while, said of the engines produced by the Company:-

> "They are the best constructed rotary engines which have ever been built."

- - -

Cooperation by the Company with Ordnance Department officials has continued since World War I. Throughout the 1920's the Company took part in formulating production schedules for 3-inch, 4-inch and 5-inch shells. During the 1930's the Company cooperated over a period of years in devising contract forms that could be used should an emergency arise. These forms were:-

1) Adjusted compensation contract.
2) Contract for supplies -- (fixed price).
3) Contract for construction -- (fixed price).
4) Evaluated fee construction contract.
5) Evaluated fee construction sub-contract.

More recently the Company participated in the Ordnance Department's industrial preparedness program. As early as May 31, 1935, the Company worked out production schedules for 700,000 cartridge cases for 2.24-inch tank guns. At the same time it developed production schedules for 8,302,000 cartridge cases for 75 MM. shells. Late in 1939 it developed a production schedule for machining 105 MM. High Explosive Shells, and a production study to manufacture these shells on the basis of 150,000 units a month.

- - -

The earliest contract received by the Company during World War II was one for the machining of 100,000 bodies for the 40-lb. high-explosive, aircraft bomb, this for the British Purchasing Commission, under a sub-contract.

The capability of the Company to perform difficult engineering problems was demonstrated dramatically and frequently during the years 1940 - 1945. In the detailed reports that follow, an attempt has been made to catalog these achievements but special mention is made here of the following:-

The Company developed the manufacturing procedure and techniques for, and was the first quantity producer of, the Potentiometer for the Radar Continuous Sight used by the United States Signal Corps. It also was among the first producers of Gear Assemblies for the same device. During the research on this equipment in the Company's Development Department, more than 150 changes were made in designs and specifications. Pawl-cutting tools, designed by the Company were so successful that the prime contractor urged their use by other producers of the same equipment.

- - -

The Company was among the first producers of some 20 different parts for the breech block of the 105 MM. Howitzer, and sub-contracted the production of some nine other parts, also for the 105 MM. Howitzer. It produced all its own tools, and developed its own manufacturing processes.

- - -

So precise was the Company's tool and production procedure that not a single one of a total of 55,000 of the .45 Caliber Automatic Pistol that it produced, failed to pass Ordnance inspection and tests.

In connection with this item of production, the Company -- through long familiarity with manufacturing procedure -- was able to devise a system of forecasting production of the Pistol in its own plant. This system was so reliable that it was adopted as standard in the industry and has since been used by the Ordnance Department in procuring other small arms equipment.

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

The Company was among the first producers of an item used by the United States Navy in the coding of messages. Information about this item still is "restricted and confidential", but it may be said that the Navy Department after a million-cycle test of the item, pronounced it "as good as, or better than" similar items made by other facilities.

For this item the Company made its own tools and electrical testing equipment, and trained Government inspectors in their duties.

The Company still was producing this item for the Navy on November 1, 1945, this being one of two contracts on which it had not received a total cancellation following the capitulation of Japan on August 14, 1945.

- - -

To the accomplishments of The Union Switch & Signal Company must be added the work it did on the engineering and production development of "secret weapons" for the Army Air Forces. One of these -- the AZ-1, or "Azon" -- was a tail assembly for high-angle, dirigible bombs of 1,000 pounds weight. Another was the AZ-2, which was to be used on bombs of 2,000 pounds, while a third was the VB-3, or "Razon", a type of tail assembly that permitted control of the bomb in free fall. The control of all three of these devices was by means of radio installed in the bombing plane. The first two bombs were controlled to the left or the right -- or along the azimuth -- while the VB-3 could be controlled both along the azimuth, or in range.

The "Azon" is credited with improving the precision of aerial bombing, especially on long, narrow, targets such as bridges, and it was used with telling effect -- according to

official reports made public following Japan's surrender -- to destroy the Avisio Viaduct near Rome, and to cripple German supply lines through the Brenner Pass. It also was used with marked success in Burma.

The AZ-1 was produced in a considerable number; the AZ-2 was produced in a limited number for experimental purposes, while the VB-3 was still being produced by the Company on November 1, 1945, but no reports of its use in actual bombing operations against an enemy had yet been made public.

- - -

The Company's Research and Development Departments -- throughout the war -- also did much work on certain war materiel which it is not permitted to mention in this report. However it may be said that such work as was done, either under special orders from the National Defense Research Committee of the Office of Scientific Research and Development, or for other Governmental agencies, proved to be of great value, and was accepted. The Office of Scientific Research and Development functioned within the Office of Emergency Management and was responsible to the President of the United States. It was this office that handled the development of the atomic bomb and other top flight war weapons and secrets.

- - -

All branches of the armed services of the United States were served -- during World War II -- by materiel produced by the Company. One of the items produced by the Company in considerable number was the hub Spider, which with its Barrel -- also produced by the Company -- was used on hydromatic propellers with which the Air Force planes, from trainers to heavy bombers -- were equipped. The Spider was said to be one of the most intricately machined items produced in the United States during the war. The Barrel also was an intricately machined piece. Great care had to be exercised in the operations on both pieces. They are discussed in a special section of this report, to be found on Pages 40 - 74.

- - -

The significance of the Company's production of special war materiel is not fully interpreted by citing its dollar value, its unit volume, or by stressing the engineering skill that made it possible. Very frequently the Company was advised that speed of production was the most urgent need -- and speed was another of the Company's major achievements. For example:-

1) With a daily output of some 650 Pistols, the Company consistently ranked second in the monthly volume of all producers in the country engaged in the manufacture of the .45 Caliber Automatic Pistol.

2) All production and shipment schedules over which the Company had any control -- whether for hydromatic propeller parts, 20 MM. or 37 MM. Shells, component parts for the 4.2 Chemical Trench Mortar Fuze, the Navy's coding device item, radar parts, cascade inverters for airplanes, or parts for light tanks -- were met, and often exceeded.

- - -

Through familiarity with shell manufacture -- gained as a supplier, at first, for the British Purchasing Commission -- the Company promptly became the largest producer of 20 MM. H. E. Shells in the Pittsburgh Ordnance District. Production was maintained consistently at 1,200,000 shells per month, a total of more than 35,000,000 being shipped by the Company.

- - -

During the winter of 1940 - 1941, the Company filled a rush order for the machining of 100,000 bodies for 40-lb. H. E. aerial bombs, half the contract being sub-contracted to the Westinghouse Air Brake Company.

- - -

When an emergency need arose for essential parts for the Army's .30 Caliber Carbine, the Company set up an entirely new department, and produced three major parts for approximately 100,000 of these carbines within a period of six months.

Working closely with procurement officers of the Army Air Forces, the Company was able to deliver the first Cascade Inverter nine days before it received its formal contract.

- - -

Similarly the Company was tooled up and ready to produce Ignition Harnesses -- or radio shields for airplane engines -- in advance of receiving a contract. As a result it was able to ship these shields at the rate of 2,700 a month, quickly and when the need was greatest.

- - -

With the increased production of airplanes a first essential of the nation's war program in 1941 and 1942, the Company promptly achieved an output of 4,000 hub Spiders and Barrels a month for the hydromatic propellers to be used on these planes. Maximum monthly output was 3,676 Spiders, 3,756 Barrels.

- - -

The cooperation of the Pittsburgh Ordnance, and of other Ordnance districts as well, in expediting procurement of raw materials, machines, etc., was invaluable in enabling the Company to meet schedules on its various contracts.

- - -

The Company frequently broke bottle-necks for other producers of war materiel as an added contribution in its all-out war effort, this despite its intensive production and its utilization of every device that would insure consistently speedy and good production. National producers were supplied by the Company with parts so that they could keep moving on such equipment as the Radar Continuous Sight, the .30 Caliber Carbine, Chemical Trench Mortar Fuze, .45 Caliber Automatic Pistols and the Navy's coding item.

While engaged in the manufacture of the .45 Caliber Automatic Pistol, the Company engaged in more than 300 individual transactions involving the loan of raw materials, tools, fixtures and gages, to keep production moving at all facilities. The Company also devised a system of inventory control -- as has been stated -- which proved so successful in accurately forecasting pistol production that it was adopted by all other producers in the country.

- - -

The Company's regular production of railroad signaling equipment also was stepped up, this equipment also being held to be of the utmost importance to the war effort of the nation. Major items produced included apparatus for Centralized Traffic Control, Coded Track Circuit Control, Inductive Train Communication, car retarders, automatic block signaling, interlocking

	Item	Production Began	Production Concluded
(*)	40-lb. H. E. Bomb Body - (for British)	1940	1941
(*)	Tail Locating Studs - Booster Casings - Suspension Lug Pins	1941	1942
(#)	4.2 Chemical Trench Mortar Fuze Parts	1940	1943
(*)	Hub Spiders and Barrels for Airplanes	1941	1945
(#)	20 MM. H. E., A-A Shell	1941	1945
(*)	105 MM. Howitzer Gun Parts	1941	1945
(*)	Gudgeons, Nuts, Bolts and Supports for M-3 Medium Tanks	1941	1942
(*)	Parts for 20 MM. and .50 Caliber Machine Guns - Collars and Shells	1941	1943
(%)	37 MM. Shell - M63	1942	1942
(*)	Catches for 57 MM. Gun Mounts	1942	1942
(*)	Items for Radar Continuous Sight:		
	Potentiometers	1942	1943
	Gear Drawer Assemblies	1942	1943
	Miscellaneous Parts	1942	1943
(%)	.45 Caliber Automatic Pistol	1943	1943
(*)	Nut for Airplane Motors	1943	1943
(%)	Cascade Inverters for Airplanes	1943	1945
(*)	Ignition Harness for Airplane Motors	1943	1944
(%)	Dial Wheels - (U. S. Navy) - /NOTE!/	1943	(NB)
(%)	.30 Caliber Carbine Parts	1943	1944
(%)	AZ-1, or "Azon"	1943	1945
(%)	AZ-2	1944	1945
(%)	VB-3, or "Razon"	1944	(NB)

- -

(Table continued on next page)

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

(Table continued from Page XV)

	Item	Production Began	Production Concluded
(%)	20 MM. A. P. - (Solid) - Shot - M95	1945	1945
(*)	Parts for "T-1" Air Compressor	1944	1945
(%)	Extrusion Press Heating Unit Parts and Assemblies	1936	(NB)

- - -

(*) Sub-contractor.

(#) Held original contract, sub-contracting part of production to Westinghouse Air Brake Company, but retaining production of certain component parts -- In the case of the 20 MM. H. E., A-A Shell, held original contract, then was sub-contractor to Westinghouse Air Brake Company for 14,400,000 pieces, later again becoming prime contractor for item.

(%) Prime contractor -- In the case of the Radar Continuous Sight, aided in development of items and manufacturing procedure -- In the case of AZ-1, AZ-2 and VB-3, not only was prime producer but aided in development from original design and developed for production -- In the case of the Extrusion Press Heating Unit Parts, The Union Switch & Signal Company is the sole producer of such unit parts for manufacturer of the presses.

/NOTE!/ -- In certain copies of this report the section dealing with the production of this item for the Navy is deleted since the item still is a "secret and confidential" one, information about which must not be released.

(NB) Production still continuing on November 1, 1945.

- # - # - # - # - # - # - # -

THE EFFECT OF THE WAR

UPON

THE UNION SWITCH & SIGNAL COMPANY

--o--

1) Personnel Increases and Training

2) Measures for Protection of Personnel

3) Protection of the Plant

--o--

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

With the receipt by The Union Switch & Signal Company of orders for the production of various items of materiel to be used in the prosecution of the war -- (as far back as mid-1940 when the British Purchasing Commission was placing orders for the machining of 40-lb. Bomb Bodies) -- increases in personnel to handle this new volume of business were necessitated.

For a while it was sufficient to transfer skilled workers in the plant to the new jobs but, as contract after contract was taken on, and the workings of the Selective Service Act drained the male workers from the plant, it was necessary to secure replacements -- from the semi-skilled as well as from the unskilled classes.

The Company was among the first in the District to cooperate with the Pittsburgh Board of Education which supervised the Government's War Production Training Program in the Vocational High Schools. The Company assigned six engineers and technicians for the purpose of providing the program with an instruction staff. The Company also worked closely with the United States Employment Service in obtaining prospective students for the courses, while other Company representatives interviewed suitable applicants for jobs. Approximately a thousand workers were obtained from this source alone.

- - -

Indicative of the effect of the war upon the Company was the gradual replacement of male workers by women in all but heavy labor and specialized skills. The number of employes on all payrolls also increased, from an immediate pre-war monthly average of 1,591 -- (for the year 1939) -- to a war-time monthly average peak of 5,301, for the year 1944.

- - -

In the tables which follow are given the average monthly employment figures for the Company for the years 1939 through 1944, together with figures that give the actual number of employes on Company payrolls -- (as of the close of business on December 31) -- for each of the years:-

Monthly Average Number of Employes - All Payrolls

Year	Total No. Employes	Number of Men	Number of Women	Approx. % Women All Payrolls
1939	1,591	1,377	214	13 1/2%
1940	1,962	1,681	281	14 2/3%
1941	2,827	2,456	371	13 2/3%
1942	3,779	3,311	468	12 1/2%
1943	5,217	3,599	1,618	31%
1944	5,301	3,781	1,520	29 2/3%

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Actual Number of Persons - All Payrolls
on December 31:

Year	Total No. Employes	Number of Men	Number of Women	Approx. % Women All Payrolls
1939	1,836	1,569	267	14 2/3%
1940	2,066	1,786	280	13 1/2%
1941	3,590	3,147	443	12 2/3%
1942	3,770	3,213	557	15%
1943	6,294	3,988	2,306	37% (*)
1944	4,724	3,534	1,190	24 2/3%

(*) In December, 1943, employment reached its war-time peak of 6,374 employes, of whom 2,350 were women.

- - -

As will be seen from the figures for the monthly average of employes on all payrolls, there was an increase in personnel -- between 1939 and 1940 -- of 371 persons, of whom 67 were women. Between 1940 and 1941, the increase was 865. Of this, 90 were women. For the next year the increase averaged 952. Of this figure 97 were women. The sharpest increase in the monthly average of personnel came between 1942 and 1943, being in the amount of 1,438. Reflecting the influx of female labor into war industry was the fact that, of this number, a total of 1,150 women was added, or approximately 80% of all persons taken on by the Company as employes.

- - -

During the year 1943 to 1944, the average monthly increase in employes amounted to only 84, while the total number of women employed fell off by 98. This meant that altogether the number of males on the payrolls had increased -- during 1944 over 1943 -- by 182. In another part of this section of the report it will be seen that -- as of December 31, 1944 -- the number of discharged veterans hired by the Company, and on the payrolls at that date, was 196. Of this number 95 were former employes of the Company. A total of 434 veterans in all had been hired by the Company up to December 31, 1944. Since former servicemen were not affected by the rules applying to civilian labor, i. e., having to apply for transfer from one job to another, or the receipt of permission to relinquish a job -- especially one in a war industry -- there was a considerable turnover in this class of labor.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

- - -

A further study of the tables on Pages 3 and 4, also discloses that while the average monthly number of employes during 1939 was 1,591, the actual figure at the year's end reflected the increased employment due to the increase in activity at the Company's plant. The same was true of the next year, but here the demands of Selective Service are reflected in that, although the average increase in male employes was given as 304, the actual increase, according to the year-end figures, was 217.

These figures closely correspond to the experience tables for war industries in other areas where the number of available workers was about equal to that in this area. As the demands of the armed services increased, there was a consequent heavier drain on manpower. Women were hired to fill the vacancies, or to assume jobs that required special skills and deftness -- jobs that could best be filled by them after preliminary training. This especially was true of the first two full years after the entrance of the United States into the war.

- - -

At this point it might be interesting to note that when the demand for skilled workers was the greatest, the Company made an appeal to Pensioners -- (former employes of the age of 65 or over) -- and recalled, and re-employed a total of 52 such persons during the war period. Many served in supervisory capacities.

- - -

The year 1944 also reflected the drift into war work of discharged veterans, and of those men required under War Manpower Commission rulings to take jobs in essential industries. The decrease in women workers during 1944, also was indicative of the return to home duties of those women who had taken their place in the production lines of essential industry.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The demands of the armed services for manpower were heaviest during the first years of the war. This also was the time when the need for production was greatest. About 20% of the original crews in various departments thus were lost to the Company, an average of 35 men and women leaving during each of the months of 1941, 1942 and 1943, while in 1944 -- just after the invasion of Europe -- the number increased slightly.

- - -

The end of hostilities -- immediately after the capitulation of Japan on August 14, 1945 -- brought cancellation of all but one of the contracts for war materiel which the Company had held. On August 25, cancellation of one contract resulted in 633 persons in one department being laid off. Of this number 253 were sent to the plant of the Westinghouse Air Brake Company, Wilmerding, Pa., while 130 were re-hired by The Union Switch & Signal Company for work elsewhere in the plant. Many of the laid-off workers returned to their former civilian jobs.

- - -

As of September 1, 1945, the number of employes on all payrolls stood at 4,122, of which number 2,941 were men, and 1,181 were women. Of a total of 654 former servicemen hired by the Company, 364 still were on the payrolls. Of this number 97 were former employes of the Company.

Labor turnover fluctuated between 1% and 1 1/2% per month for the first years of the war, gradually rising to 4% during the latter half of 1944 and the first part of 1945. This was due, in some measure, not only to the demands of Selective Service but also to the scarcity of skilled and semi-skilled labor, or that class of labor that could absorb and retain the necessary training. This also reflected the scraping of the bottom of the manpower reserve barrel.

- - -

The Company gave special employment preference -- especially in the more confidential items of production -- to those women who had immediate relatives in the armed services, as well as to discharged veterans.

- - -

On December 31, 1944, the Company's service flag carried stars for 1,426 employes in the service, and Gold Stars for 30 who had died in service. As of August 1, 1945, the service stars had increased to 1,572 and the Gold Stars to 47, while as of September 1, 1945, there were stars for 1,615 employes in the service, and the Gold Star count was 48.

- - -

From the beginning of the war until July 15, 1945, the Company investigated and "cleared" a total of 31 aliens, many of whom had been in the Company's employ for many years. Of the 31, a total of 14 still were employed by the Company as of July 15. Of the remaining 17, one had died, while others did not report for work, had quit their jobs or had received their final naturalization papers.

- - -

With the increased number of women employed, it was necessary for the Company to request special permission from the Pennsylvania State Department of Labor to extend the working hours for female employes to 48 hours a week -- and in case of emergency to 56 hours. Notification also had to be made to the State in the case of girls over 18 years of age who were working in excess of 48 hours per week.

- - -

Special provisions were made for food service for employes. Food counters were set up in several locations to furnish meals. Where no such counters were provided, special food trucks made scheduled tours daily. Between 75% and 80% of the employes patronized these special services.

In the recruitment of labor a serious effort was made at all times to attract mechanically inclined male workers -- garage mechanics, radio and refrigerator repairmen and the like -- even though these men had had no previous machine shop experience. The employment records of the Company show that the male production crews were built up from the ranks of clerks, bakers, truck drivers, barbers, clergymen, musicians, attorneys, dentists, ball players, undertakers, school teachers, insurance agents and others who had never worked in a factory until hired by the Company.

* * *

Cooperation with the War Manpower Commission was further evidenced by the Company in the setting up of special training courses, commencing in 1942. The JIT (Job Instructor Training) course, designed to improve supervisory methods in the plant, had 44 students in the first class. The second JIT class had 72 students. The JMT (Job Methods Training) course which followed, had 41 students, while the second JMT course had 107. The purpose of this course was to introduce efficiency into the methods for performing various production operations. Each of these courses required ten hours, and each was conducted on Company time with the Company's own instructors in charge. A third course -- JRT (Job Relations Training) -- of 60 hours duration, began early in 1945, with four men taking the course to be trained as instructors for future classes.

\- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

In general the Company conducted no apprentice training schools. The supervisors in each department were specifically charged with the training of all new employes. Some few departments were allowed exceptions to this plan, covering certain operations.

- - -

Every effort was made to combat absenteeism and for women employes a woman was engaged as Special Personnel Contact. Her work was most effective and the absentee rate among the women -- which had run as high as 7.5% at one time -- was reduced to under 5.3% within a few months. Absenteeism in general in the plant averaged between 4% and 6% a month, but increased sharply at certain times, and during certain seasons, with there being an especially noticeable increase following V-E Day, early in 1945.

- - -

A variety of miscellaneous services were maintained by the Company to aid employes. Among these were:-

Obtaining necessary priorities for employes needing their own personal tools; the purchase of these tools, and their resale to employes through payroll deduction.

Assistance in obtaining needed tires, gasoline and work shoes for employes; securing of gasoline stamps and applications.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Maintenance of an advisory bureau to assist the employes in securing of housing.

Obtaining the cooperation of transportation operators in providing special bus, trolley or train service for employes at shift hours.

Various employe social functions, such as the annual picnic, dances, roller-skating clubs and parties, music, a Christmas party for employes' children, etc.

Prior to the inauguration of the Withholding Tax, special agents of the Federal Internal Revenue Department were brought to the Company's plant to assist employes in filing Income Tax Returns.

- - -

There are two organizations within the Company, membership in which is limited to personnel long in the employ of the Company. One, the Senior Veterans' Association, composed of employes with more than 21 years service, had -- as of August 1, 1945 -- a membership of 672. Of this number 165 were pensioners of the Company. The other organization -- The Junior Veterans' Association, composed of employes with from 10 to 21 years of service -- had a membership of 335 on August 1, 1945.

- - -

Each man or woman who left the Company's employ to enter the armed services, was given a Service Book which was presented to their family. A letter from the Company accompanied each book, thanking the employe for their work for the Company and expressing appreciation of their service to their country.

All discharged servicemen who were former employes and who returned to work for the Company were processed through the Personnel Office. Here it was learned what new, or special, skills they might have acquired, and how this could fit them into better positions, either at their former jobs or bring them some advancement.

The work of the Personnel Office did not stop here, however, a special check being maintained on these men to see that they were getting along in their work; to ascertain that they were contented or to fit them in to their return to civilian occupations at the plant. If, as stated above, they had developed special skills, these were recognized and every opportunity given them for further advancement.

* * * * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Measures for Protection of Personnel

Throughout the period of production of war materiel by the Company -- from 1940 to August 15, 1945 -- all of the work was performed without a single fatal accident.

For the year 1940 there were only 15 accidents. During 1941 there were 37, and in 1942 there were 89. In 1943 -- the year of peak employment -- there was a total of 118 accidents. This figure fell off to 90 during 1944, while up to June 30, 1945, there had been 40 accidents. In each of the years the Frequency Rate and Severity Rate averages for accidents at the plant, were well below the national averages compiled for the Miscellaneous Metal Products Industries by the National Safety Council.

- - -

In the table to be found on the next page are given the statistical figures for accidents for the period. The figures on employment differ somewhat from those in the tables on Pages 3 and 4. This is due to the fact that those tables are for the monthly average number of employes, and employes as of a certain date, while shown in the following table are the annual average number of employes throughout the years:-

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Year	Employes Men	Employes Women	Number of Accidents	Actual Days Lost - plus	Penalty Days	Frequency Rate	Severity Rate
1940	1,657	280	15	510	- -	3.84	.13
						12.40 *	.94 *
1941	2,416	371	37	1,057	1,800	6.19	.48
						16.61 *	1.30 *
1942	3,230	469	89	1,169	9,300	10.66	1.25
						18.88 *	1.30 *
1943	3,529	1,626	118	1,069	6,150	9.78	.60
						15.71 *	1.98 *
1944	3,721	1,522	90	1,678	600	7.23	.18
						18.37 *	1.02 *
		-- and, up to June 30, 1945 --					
1945	3,577	1,181	40	611	- -	7.03	.107

- - -

(NOTE: Figures underlined and marked with an asterisk are those of the national average for the Miscellaneous Metal Products Industries compiled by the National Safety Council. No national average figures available for the first six months of 1945.)

- - -

In the case of serious injuries, such as the loss of the use of a hand; loss of portions of a finger, etc., an extra charge of "penalty days" was made against the Company, although these "penalty days" are not in actuality entirely lost from work.

- - -

The frequency rate of accidents in departments engaged in the production of war materiel, in which a preponderance of the workers had had no previous factory experience, and in which most of the work was performed on machines, was consistent with the record in other old, long-established, departments.

- - -

Constant efforts to bring home to the workers the necessity for alertness and care in the handling of tools, machines, fixtures, etc., bore fruit in that the accident and severity rates, as has been stated, were both well below the figures set up for the national averages. Many safety devices were installed, or had been in use in the plant. One special safety device used on drill presses, was developed and installed for women workers. This was a shield device of wood which prevented the worker's hair from coming into contact with moving parts, should the worker accidently, or through carelessness, not wear special safety caps and/or nets.

- - -

There was only one instance of occupational disease in the plant during its work on war materiel. This was in one department where an epidemic of oil dermatitis affected a great many of the male machinists and a few of the women checkers. It required some

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

three months checking to determine fully the cause of the malady, which caused eruptions on the hands and arms, with consequent suffering and loss of time. It was found that most of those affected were new to machine shops and not conditioned to the constant exposure to oil and grease which the particular work involved.

The management instituted, through the Medical and Safety Departments, regulations which eliminated the problem. These included washing with special soaps and the use of skin creams to exposed parts of the body. This washing and use of creams was ordered for the workers to be followed three times a day. Changing to clean underwear, and a more frequent change to clean work trousers during the week, also was ordered. Those few persons who failed to respond to treatment were classified as allergic to oil and were transferred to other departments.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

- - -

In a survey conducted at the plant by the Industrial Hygiene Foundation of America in 1943, the investigators reported:-

> "It -- /the survey/ -- disclosed an alert policy for the prevention of occupational diseases. Nearly all of the operations where poisonous chemicals are used were found to be free from hazard. The control of airborne contaminants in most of the departments is excellent."

* * * * *

Protection of the Plant

Plant protection against sabotage became increasingly essential as the Company took on contract after contract for the production of war materiel. The number of guards was increased from 17 -- in 1940 -- to 52 by the end of 1943. As of June 30, 1945, there was a force of 35 guards, three sergeants and one Captain, or a total of 39 in all. Special guard houses were erected at strategic points on the Company's property, while the guards were uniformed and armed, each guard assuming complete authority over the area he patrolled.

While the guards -- in theory -- came under the jurisdiction of whatever division of the armed forces was receiving the largest dollar volume of the Company's products at the time, this led to overlapping of authority in some instances. At times the plant protection force was controlled by the Federal Bureau of Investigation, the United States Navy, the Third Service Command, the United States Army Ordnance Department and the Army Air Forces, in the order named.

- - -

Some 400 additional employes augmented the system of guard patrol, serving as Auxiliary Guards, Auxiliary Firemen, or as members of Auxiliary First Aid Units. So efficient was the work of the Company in this respect that -- in March, 1945 -- it received

the coveted National Security Award, conferred by the United States Office of Civilian Defense as the highest honor it could bestow on any industry. This award was given for the "establishment of a superior standard of protection and security of production, employes and property."

- - -

In addition to the above features of plant protection the Company also set up:-

A badge identification system for all employes.

A visitor recording system, checking visitors to the plant, both in and out, and accounting for their time in the plant.

Fingerprinting of all personnel.

Preparation of a course of instruction for guards.

Installation of 120 new flood lights, increasing the total number in use at the plant to 180.

Erection of iron gates at entrances, and steel fences around the plant.

Installation of additional fire-fighting equipment.

Imposition of restrictions on movement of personnel throughout the plant, and the guarding of certain "secret areas" at all times, with special means of checking persons in and out of these areas.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MACHINING OF 40-lb. HIGH-EXPLOSIVE,

AIRCRAFT BOMB BODIES

(American Steel Foundries Contract)

--o--

First Shipment Made Fifteen Days Following Receipt of Order -- Contract Completed Within Six Months, Production Exceeding Delivery Schedules -- Half of Contract for 100,000 Bodies Sub-let by Company so as to Free Machines and Equipment for Other War Production.

--o--

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

In the latter part of 1940 -- following several months of negotiation -- The Union Switch & Signal Company began production of an item of ordnance for the British Purchasing Commission, under sub-contract to the American Steel Foundries, Chicago, Ill. The work called for the machining of the bodies for 40-lb. High-Explosive, General Purpose, Aircraft Bombs, intended for use in the African campaign. A contract for 100,000 bodies was given the Company by the prime contractor on September 30, 1940. Fifteen days later the first shipment of the bodies was made, the contract being completed within six months.

The first inquiries regarding this work were made in August, 1940, the Westinghouse Air Brake Company, Wilmerding, Pa., being the negotiator and making quotations on August 30. On September 27 it was decided that -- for various reasons -- the order should be placed with The Union Switch & Signal Company. This was done on September 30, with the provision being made by the Company that half the bodies would be sub-contracted by the Company to the Westinghouse Air Brake Company. It had become apparent by this time that our own Government would require a vast amount of ordnance production. The sub-contracting of a portion of the order would leave the Company in a position to use its engineers and machine operators in the production, pioneering, or development of products that might be needed by the United States.

Space within the existing factory structure was found by the Company for the establishment of a production line on this contract, some 1,300 square feet in one of the machine shops being allocated for the purpose. Jigs were made in the Company's tool room and existing machinery was assigned to the work.

- - -

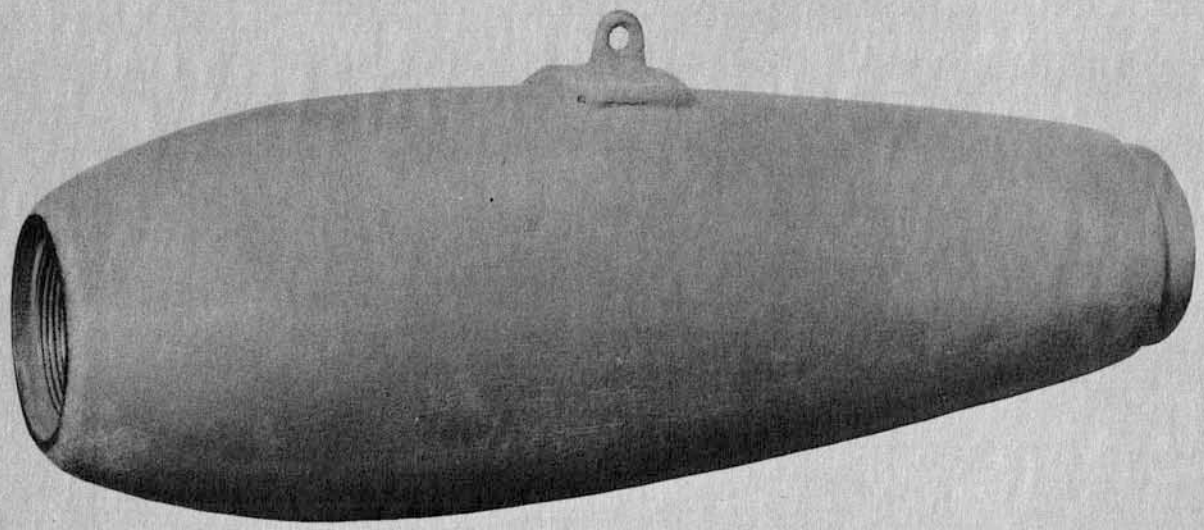
The bomb bodies were produced by the Company at the rate of 10,000 a month, and a similar number were being produced by the Westinghouse Air Brake Company. Shortly after the shipments were started they were halted because of the inability of the prime contractor to furnish castings in quantity sufficient to enable schedules to be met. This difficulty was overcome, however, with the result that the entire contract for 100,000 bodies was completed by June, 1941.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

* * *

Description of the Bomb. Used extensively by British troops in the early stages of the war in Africa, the bomb was dropped from aircraft on advancing troops. It carried an impact, nose-fuze, and a sheet metal tail fin was attached to the body.

* * *



40 LB. H.E. GENERAL PURPOSE
AIRCRAFT BOMB

C-41017

MANUFACTURING OPERATIONS:

The body was machined from a steel casting as follows:- Face, bore, counterbore and tap the tail end of the body; similarly machine the nose end; insert plug in base, tighten and weld; weld suspension lug on side of body; pressure test under water for porosity; apply special rust-proof coating to interior surface; check and gage; pack and ship.

- - -

During the above operations the pieces were constantly checked by Company inspectors, the final inspection being made by a representative of the British Purchasing Commission.

- - -

Among the devices developed by the Company was a special rotating table, driven by an air motor and controlled by a foot valve. This table rotated at a speed that permitted the turning of the bomb body while the plug was being welded into the base. Yet another fixture was used to locate the hanger lug for welding. Both devices solved an early hold-up in production.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Another special fixture used by the Company held the body in a vertical position by means of two sets of jaws, one near the base, the other towards the nose. Through the use of this fixture and of a special facing, turning and chamfering tool, all machining operations were completed on the nose end, the fixture indexed 180 degrees, after which all machining operations were performed on the base.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING DIFFICULTIES:

One of the earliest difficulties encountered by the Company, and also by the Westinghouse Air Brake Company, was the inability of the British Purchasing Commission to furnish gages to be used on the work. Several lots supplied by a New York firm were found to be inaccurate. The master gages were made by the Westinghouse Air Brake Company. After these had been approved by the British, working gages and fixtures were made and supplied to The Union Switch & Signal Company. The Company made its own jigs, however.

- - -

The castings of the body -- during the early weeks of the contract -- varied considerably in the composition of the steel from which they were cast. Some of the steel was too brittle to permit of clean threading, while the variations of hardness burned

up many of the cutting tools. Some of the castings also were out of balance, causing trouble in the boring operation, while others were rusted on the inside, necessitating an additional buffing operation. The British Purchasing Commission insisted that the interior of the bomb body be kept free of rust spots, and from sand, scale and fins. Many of the castings also were porous and would not pass the air-pressure tests. Such rejections were not charged against the Company. The rejections for defects in machining were very few.

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

While the prime contractor was unable, at first, to supply castings in sufficient quantity to enable the schedule of 10,000 bodies a month to be kept, every production schedule over which the Company had any control was met. In fact, production became so rapid that huge quantities of the finished bodies had to be stored in the plant for a considerable period of time until the British Purchasing Commission could complete arrangements to move them.

* * *

At the start of the contract the production crew consisted of ten men -- die setters, machine operators and inspectors, plus four packers and laborers -- working a single eight-hour shift. This was later expanded to between 35 and 40 men, operating three shifts.

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TAIL LOCATING STUDS - BOOSTER CASINGS

SUSPENSION LUG PINS

(National Tube Co., Orders)

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

--o--

First Two Items Produced Under Sub-contracts Beginning Late in 1940 -- Later Company Made First and Third Items Under Direct Contracts from National Tube Company

--o--

On September 26, 1940, following inquiries made several days before, The Union Switch & Signal Company made quotations for the production of 8,300 Tail Locating Studs, and 8,100 steel pipe Booster Casings, receiving orders for the production of these two items in the amounts named on November 22, 1940. The orders were placed with the Company by the Westinghouse Air Brake Company which, at that time, was in receipt of orders for the production of a number of items from the National Tube Company, Christy Park Works, McKeesport, Pa. The material for both items was to be supplied by the National Tube Company.

- - -

Delivery of 50% of each order was asked for before January 27, 1941, with the balance to be delivered before June 1, 1941. The Tail Locating Studs were used to anchor lock nuts which held in place the fin on the 100-lb., and the 200-lb., bombs used by the United States Navy. The Booster Casings also were used in Navy Bombs of 1,000 pounds.

- - -

The first shipment of the Tail Locating Studs was made in the amount of 4,500 pieces on January 28, followed by shipment of 3,800 pieces on January 31, 1941, the order being completed four months ahead of schedule.

The first shipment of the Booster Casings was made in the amount of six pieces on January 20, 1941 -- seven days ahead of schedule -- followed by 1,440 pieces on January 31, then by 2,016 pieces on February 13. Another shipment -- of 3,024 pieces was made February 25, and a final shipment, of 1,753 pieces was made March 12, this order being completed -- with 139 pieces as overage being accepted -- a trifle more than two-and-a-half months ahead of schedule.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Then, on March 21, 1941, the Company received inquiries directly from the National Tube Company regarding further production of Tail Locating Studs. The first order for the studs was received on June 30. It called for 20,600 of the item to be delivered at the rate of 2,000 a week, commencing October 20, 1941. The first shipment went forward on August 23, in the amount of 3,335 pieces, being made a trifle less than two months ahead of schedule. The last shipment was made on this first order on October 31, a total of 23,100 pieces in all having been shipped, with the overage of 2,500 pieces being accepted.

- - -

The second direct order -- also for 20,600 pieces -- was received on July 16. The shipments, also at the rate of 2,000 a week, were to begin on December 29. The first shipment, in the amount of 18,500

pieces, was made October 31 -- two months ahead of schedule -- with the final shipment being made November 4, the order being filled in entirety, together with an overage of 3,600 pieces for a total of 24,200 pieces in all, even before shipments had been scheduled to begin.

- - -

The third order for the Tail Locating Studs was received by the Company on January 3, 1942. This was for 24,000 pieces and "Rush Delivery" was requested. Shortage of material held up the first shipment, which was not made until February 7. The order was completed -- with the shipment of 10,447 pieces -- on February 12, 1942, however, being filled in the amount of 24,000 pieces in five days.

- - -

The final order for this item was received on May 28, 1942. It called for 20,000 pieces. It was shipped complete -- including an overage of 2,600 pieces -- between June 1 and 9, 1942.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

In the matter of manufacture of the steel Suspension Lug Pins -- also used on Navy Bombs -- the Company received an order on July 5, 1941, for 20,200 of this item, to be shipped at the rate of 2,000 a week. The quotations made on the Tail Locating Studs applied equally to the Suspension Lug Pins.

- - -

Due to delays in the receipt of material, the first shipment of the Suspension Lug Pins was not made until December 1, 1941. The last shipment on the order -- including an overage of 142 pieces -- went forward on February 26, 1942.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

COMPONENT PARTS FOR FUZE HEAD

of

4.2 CHEMICAL MORTAR SHELL

--o--

Company sub-contracted Initial Order for Assembled Fuze by Assumed Production of Eight Parts -- Also Manufactured Some Parts on Subsequent Orders -- Special Tools Produced in Own Plant -- Production Schedules Met -- No Parts Failures Reported in Government Tests

--o--

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Late in 1940, The Union Switch & Signal Company began the production of eight different parts entering into the final assembly of Fuzes used on 4.2 Chemical Trench Mortar Shells. During the following thirty months a total of nearly 4,154,000 of these parts were produced and shipped by the Company.

- - -

The eight different parts were produced in three departments at the Company's plant, the operations utilizing the facilities of screw machines, drill presses, milling machines and the plating department. The parts were shipped to the Westinghouse Air Brake Company for assembly into the body of the Fuze, together with other parts which were purchased from outside sources. Insofar as the Company had any control, all production schedules were met.

- - -

The Company, together with the Westinghouse Air Brake Company, were the first prime producers of the Fuze, which was made for the Chemical Warfare Service. Prior to the assumption of the first contract -- in October, 1940 -- only a few thousand of the Fuzes had been made, these being produced at Picatinny Arsenal, Dover, N. J.

- - -

The 4.2 Chemical Trench Mortar Shell, on which the Fuze was fitted, is designed for carrying gas, smoke screen or phosphorous incendiary charges, or for use as a fragmentation bomb. The Fuze is centrifugally armed, the necessary rotating motion being imparted by a band, or plate, attached to the base of the shell. This engages with the rifling of the mortar when the shell is discharged.

* * *

HISTORY OF THE CONTRACT AND SUBSEQUENT ORDERS:

In the spring of 1940, the Chemical Warfare Service, at Pittsburgh, Pa., began negotiations for the production of the Fuze, known as EL5 - R - 8. The negotiations were conducted with the Westinghouse Air Brake Company, but it was decided, for various reasons, that the contract should be awarded to The Union Switch & Signal Company.

On May 5, 1940, the Company was in receipt of an order for the manufacture and assembly of the component parts of the Fuze in the amount of 47,626 assembled pieces. In addition, the Company was to make, or secure, the necessary tools, gages, jigs and fixtures. Deliveries were to commence in the amount of 1,000 Fuzes by December 31, 1940, and to continue at the rate of 6,800 monthly until completion of the order.

HISTORY OF CONTRACT - (Con't.)

The Company sub-contracted the order to the Westinghouse Air Brake Company, retaining, however, production of eight of the parts. These were the Striker and Striker Head; Lock Pin; Set Screw; Guide Screw; Plug, Retainer and Slider. Production of the Fuze body and certain other parts, and procurement of certain purchased items, as well as assembly and shipment of the assembled Fuze to loading plants, all was turned over to the Westinghouse Air Brake Company. This was in September, and a purchase order was received by the Company from the Westinghouse Air Brake Company on October 21, 1940, covering the parts to be made by the Company.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

First delivery of these parts was made by the Company on December 13, 1940, while the first delivery of 15 assembled Fuzes was made on December 27, followed by an additional 1,000 assembled Fuzes on December 30, 1940.

Other shipments of the parts were made from time to time. On March 21, 1941, the initial order for 47,626 Fuzes was increased by 1,000, and on June 21, 1941, by another 2,200 Fuzes, making a total -- on the first order -- of 50,826 Fuzes in all. The final shipment of the assembled Fuzes went forward on July 2, 1941, the contract being completed slightly ahead of schedule.

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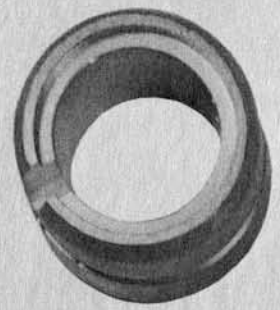


RETAINER

SLIDER

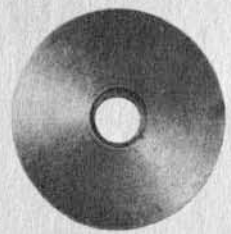
PLUG SCREW

STRIKER AND HEAD ASSEMBLY

LOCK PIN

GUIDE SCREW

SET SCREW



STRIKER HEAD

STRIKER

4.2 CHEMICAL TRENCH MORTAR FUZE PARTS MADE BY U. S. & S. CO.

Subsequently the Westinghouse Air Brake Company received orders directly from the Chemical Warfare Service, Pittsburgh, for the production of additional Fuzes. Purchase orders, covering the eight parts, were placed with the Company in amounts sufficient to cover these orders. The Purchase Orders were received as follows:-

November 11, 1941. This order was for 160,879 pieces each of the Striker Heads, Strikers, Lock Pins, Guide Screws, Plugs, Retainers, Set Screws and Sliders. The order for the Strikers was closed out at 54,471 pieces on April 16, 1942, however, while the order for the Sliders was closed out -- a week later -- at 73,309 pieces. The order for the Lock Pins was increased to a total of 169,380 pieces. The other items were shipped in full between January 27, and July 9, 1942.

- - -

February 20, 1942. A Purchase Order from the Westinghouse Air Brake Company for 400,000 pieces each of the Retainers, Plugs, Set Screws, Striker Heads, Lock Pins and Guide Screws was received on this date. First shipments went forward on June 30, 1942, while the last shipment of some of the items was made on February 15, 1943.

(Because of the lack of sufficient machining facilities by the Company -- due to the assumption of other war contracts

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

upon the entrance of the United States into the war, and because of the accelerated rate of production demanded on the Striker and the Slider -- the Company at this time ceased the production of the Striker and the Slider, this work then being done at the plant of the Westinghouse Air Brake Company.)

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April 9, 1942. Calling for 6,000 pieces each of the Guide Screws, Lock Pins, Striker Heads, Set Screws, Plugs and Retainers, this order also called for the Company to resume production of the Strikers and Sliders, each in the amount of 60,000 pieces. The necessary amount of 21/32" brass rod for the Sliders, and 13/32" cold rolled steel rod for the Strikers, was furnished by the Westinghouse Air Brake Company.

The order for the 60,000 Sliders was closed out at 21,185 pieces on December 23, 1942, while the order for the same number of Strikers was closed out at 52,724 pieces on the same date. The other parts were produced and shipped in the amounts ordered.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

May 6, 1942. An additional 7,500 pieces each, of the Retainers, Plugs, Set and Guide Screws, Striker Heads and Lock Pins, was called for in the Purchase Order of this date. On March 4, 1943, however, the order for the Retainers was increased to 8,911 pieces. The order for the Plugs had been increased -- on February 11, 1943 -- to a total of 10,100 pieces. The order was filled in the amounts called for within scheduled dates.

- - -

March 19, 1943. This last Purchase Order called for 16,000 Set Screws; 27,000 Retainers; 23,000 Striker Heads; 17,000 Guide Screws and 27,000 Plugs. With the exception that the last item was closed out in the amount of 3,497 pieces, the order was filled complete.

- - -

Under the original Contract, and the subsequent Purchase Orders, the Company therefore had produced the eight parts in the following total amounts:-

Striker Heads. . . .	648,205	Strikers.	158,021
Lock Pins.	633,706	Guide Screws.	642,205
Plugs.	631,302	Retainers	653,616
Set Screws	641,205	Sliders	145,320

Total of all pieces produced 4,153,580

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

For the most part these eight pieces were produced without difficulty. Two items did present major problems, however. These were the Striker and the Slider.

The most exacting machining operation on the Striker was the forming of the point. Here, in a length of 3/16", the point diminished from a diameter of 1/16" to 0", and the point had to be maintained directly on the centerline of the piece. The other end of the Striker was drilled and slotted. Some of the walls of the piece were very frail, requiring the utmost care in handling during operations. Both the Striker and the Striker Head were cadmium plated by the Company. The parts were assembled and riveted to form one piece, this operation being performed at the plant of the Westinghouse Air Brake Company.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The Slider, made from brass rod of approximately 5/8" diameter, had an overall length of 1½". The piece was turned, slotted and bored. After boring the piece had to maintain a thickness of wall, in the center of the diameter, of from .032" to .035". Because of the nature of the boring operations this wall thickness was difficult to maintain. During the time of stepped-up production, the percentage of rejections was quite high for a time.

Operations on the Slider had to be performed with the utmost precision since, when assembled, the piece had to move in a cross-hole in the body of the Fuze Head, and the utmost alignment and true relation-

ship with all other machining operations had to be maintained. When half-way through production, almost every piece received a 100% inspection for forming, grinding, milling and drilling operations.

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Manufacture of the other parts presented no particular problems. Great attention was paid to maintaining absolute precision in each step of manufacture, however.

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Daily production was quite high on some of the items. Approximately 50 men were employed in the various operations. When stepped-up schedules were requested, some items were produced at the rate of 2,000 pieces a day. Government inspectors were stationed at the plant during the entire period of production.

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No report of failure of any of the parts during firing tests conducted by the Government ever were reported to the Company. No new machinery was required on this production. Such special tools and fixtures as were needed were designed and made by the Company.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HUB SPIDERS AND BARRELS

for the

23-E-50 and 33-E-60

HYDROMATIC AIRPLANE PROPELLERS

--o--

Production of Intricately Machined Parts Began Before Pearl Harbor -- Special Machines Installed in Existing Plant Space Assigned to Manufacture -- Unskilled Labor Turned into Efficient Production Line -- Nearly 239,000 Items Shipped Between January, 1941, and August, 1945, to Three Contractors -- Company Praised for Excellence of Work

--o--

Two of the most intricately machined pieces of war materiel produced in the United States during World War II, were manufactured in the amount of more than a quarter of a million parts at the plant of The Union Switch & Signal Company between January, 1941, and August, 1945. These were the hub Spiders and housing Barrels for the 23-E-50 and 33-E-60 Hydromatic Propellers used on the military aircraft of the United States, from the advanced training planes to the latest type of Superfortress.

> Three shifts of workers a day, seven days a week, kept continuous stream of the two parts moving to three different prime contractors, although when production commenced the Company manufactured the items but for one company -- the Hamilton Standard Propellers Division of the United Aircraft Corporation, East Hartford, Conn.

Two sizes of the Spiders and Barrels were produced, and the workmanship on each was considered to be a "triumph in precision machining."

Altogether 121,127 Spiders and 117,409 Barrels were machined by the Company and, in addition, 280 Barrels of a special type, or a total of 238,816 pieces in all. The other prime contractors for whom the Company produced were Remington Rand, Inc., Propeller Division, and Nash-Kelvinator Corporation, Propeller Division.

- - -

The Company was reluctant to undertake the manufacture of the two parts when it was first approached in mid-1940. It finally agreed to do so and orders were placed for the special machines needed to produce 1,000 Spiders and 1,000 Barrels a month. These machines were obtained under an Emergency Plant Facilities contract, through which the Company purchased the equipment outright, the Government agreeing to reimburse the Company for its investment over a five-year period.

So great was the demand for this type of machinery, however, that the Company was unable to secure at once all of the machines to satisfy its needs, the machines being delivered, installed, and placed in operation, from time to time.

By February, 1941, enough equipment had been secured to increase production to 1,500 units of each part per month. On December 17, 1941, ten days after Pearl Harbor, the schedule originally set up again was advanced, this time to 2,250 of each part per month.

- - -

No new building construction was needed for the special department set up for production. Some 44,800 square feet of floor space formerly used as a storeroom, maintenance department, and for fabrication of certain parts of railway signaling devices, was turned over to the Spider and Barrel Department.

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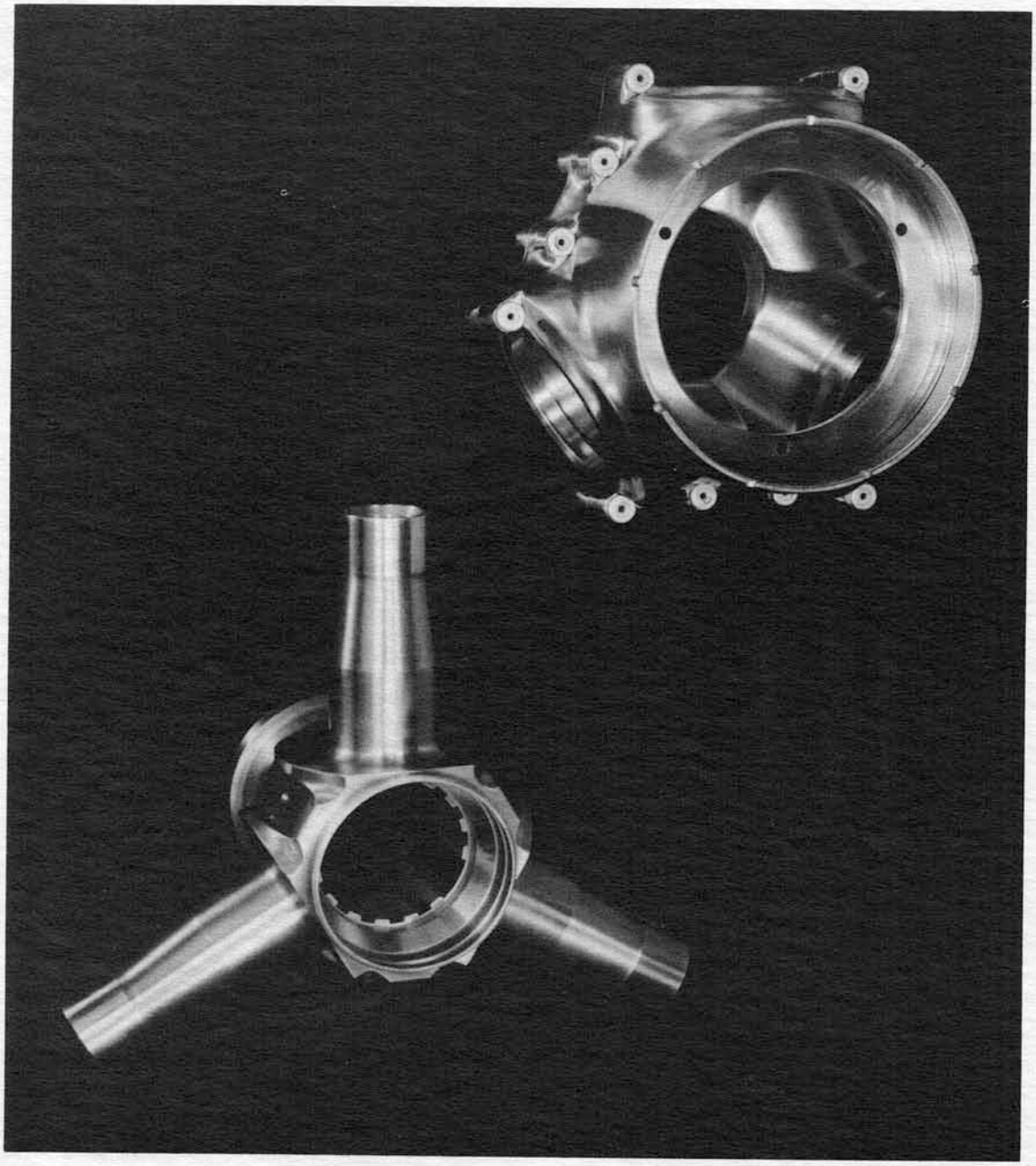

STANDARD HUB SPIDER AND BARREL
FOR HAMILTON STANDARD PROPELLER 23-E-50

It was in connection with this ability of the Company to convert existing space and facilities into a highly efficient production line turning out vitally needed parts of intricate manufacture, that caused Lieutenant General William S. Knudsen to remark, during an inspection of this department in 1942:-

"What I like about you fellows is that you took your old plant and made a REAL manufacturing institution out of it."

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Among other matters of commendation for the Company in connection with the Spider and Barrel contracts is the fact that there never has been a reported failure in operation of any Spider or Barrel manufactured by the Company; that crews of hitherto inexperienced workers were trained to perform what is considered to be among the most intricate of machining operations; that rejections decreased and production increased, and that -- insofar as the Company had any control -- all schedules, both in production and shipment, were met. Lack of machines equipment or materiel were contributing factors, in the main, for any delays in schedules. The Company made many of its tools, gages and fixtures in an endeavor to meet the demands made upon it for production.

- - -

That the performance of the Company was not unappreciated was further emphasized by the receipt of many letters from the contractors for whom it was producing. Excerpts from some of these follow:-

From the Hamilton Standard Propellers Division:-

"We received the first two spiders from your plant today, and we were greatly pleased to note the workmanship. * * * When we start dealing with any new sub-contractor, there is always doubt as to whether he will turn out the quality of work to which we are accustomed. It is very gratifying to get this reassurance."

Again:-

"We are all very pleased with the progress you have made in the last two months * * *."

- - -

From Remington Rand, Inc., Propeller Division:-

"Many thanks for the splendid co-operation you gave us in the machining of the Barrels and Spiders."

Again:-

"We, here at Remington Rand, want you to know how grateful we are to you for the splendid co-operation that your organization has given us in connection with the fulfillment of the machining of our Spiders for the past year and a half."

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS:

First Contract. Prolonged negotiations with regard to the production of the standard size Spider -- (Part # 53,644) -- and the standard Barrel -- (Part # 54,770) -- took place between The Union Switch & Signal Company and the Hamilton Standard Propeller Division, United Aircraft Corporation, East Hartford, Conn., in the early part of 1940, before the Company agreed to undertake the manufacture of the two parts. The first inquiries were made in May, 1940, quotations being forwarded by the Company on July 23, that year. Some months later -- the contract being dated December 2, 1940 -- the Company was awarded a contract for production of 10,000 each of the Spider and Barrel. Delivery of the first 100 of each was to be made in April, 1941. This was to be followed by 300 of each in May; 600 of each in June, and then shipment at the rate of 1,000 each per month through March, 1942.

Although the first shipment of the Spiders was not made until May 31, 1941, and the first Barrels until June 5, 1941 -- each approximately two months behind schedule -- the final shipments on this first contract were made from a month to a month-and-a-half ahead of the schedule, i. e., the last of the 10,000 Spiders going forward February 19, 1942, and the last of the 10,000 Barrels being shipped on February 28, that year.

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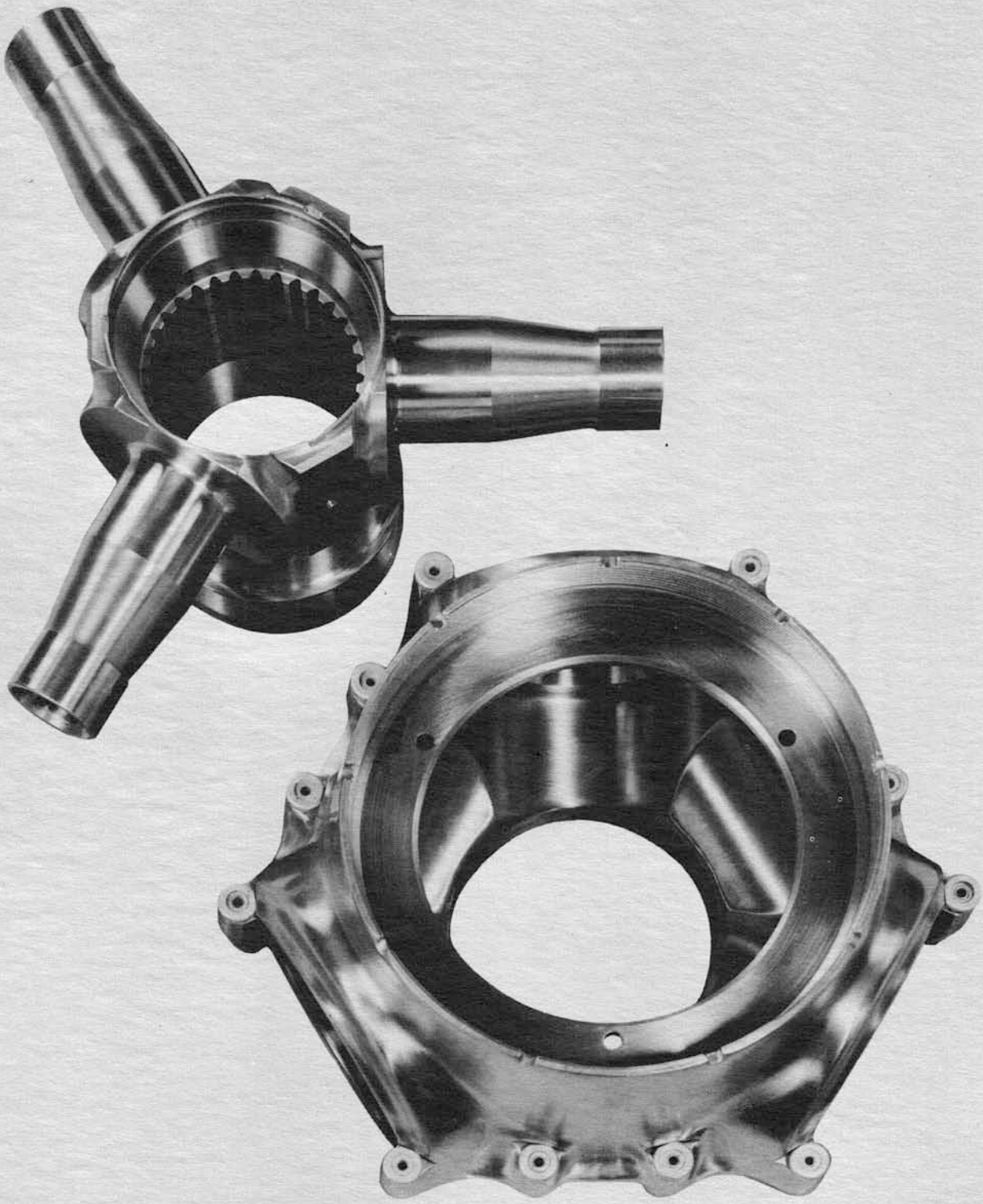

LARGE HUB SPIDER AND BARREL
FOR HAMILTON STANDARD PROPELLER 33-E-60

HISTORY OF THE CONTRACTS - (Con't.)

Second Contract. No formal inquiry was made, nor were there any formal quotations, both being made verbally. The prime contractor forwarded papers for execution on August 27, 1941, the notice of the award being received by the Company on September 10, 1941.

A slight change had been made in the design of the Barrel, the inside diameter of the lip in the arm bores being changed from 5 5/16" to 5 1/8". This called for some modification of the equipment used to produce the Barrel. A new part number was assigned to the piece, it now being designated # 56,342, instead of # 54,770.

The Second Contract called for another 10,000 each of the two parts, with delivery of 1,125 each commencing in April, 1942, followed by 1,400 of each in May; 1,500 of each in June, July, August and September, with a final shipment of 1,475 of each in October.

Because the Company had been given advance notice of the modification in design of the Barrel, the changeover was quickly made. The first Spiders were shipped February 20, and the first Barrels on March 1 -- both ahead of the schedule -- while final shipment of each of the parts was made on July 7, 1942, three months ahead of schedule.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS - (Con't.)

Third Contract. While the Company still was producing under the second contract, negotiations were started -- on March 3, 1942 -- for further production of the two parts. Quotations were forwarded March 16, and a contract for 25,000 of each part was awarded the Company on April 8. Deliveries were to begin in August, 1942, in the amount of 800 of each part, then at the rate of 2,250 of each part through the succeeding months until July, 1943, when 1,700 of each item would complete the contract.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The first shipment of each of the items was made July 7, 1942 -- nearly a month ahead of schedule. The final shipments were made on June 12, 1943, the contract being completed ahead of schedule also by more than a month.

- - -

Fourth Contract. During September, 1942, a telephone call to the Company initiated negotiations leading up to this contract. The quotations were made November 11, 1942, but the contract was not received by the Company until May 17, 1943 -- some six months later. It called for 20,075 of each part, with delivery of 600 each in May. This was to be followed by 2,700 in June; 2,750 of each in each of the next two months; 2,800 each in September, and 2,825 each in October, November and December, 1943. The first deliveries were not made until June 15, 1943, and final shipments went forward on March 31, 1944.

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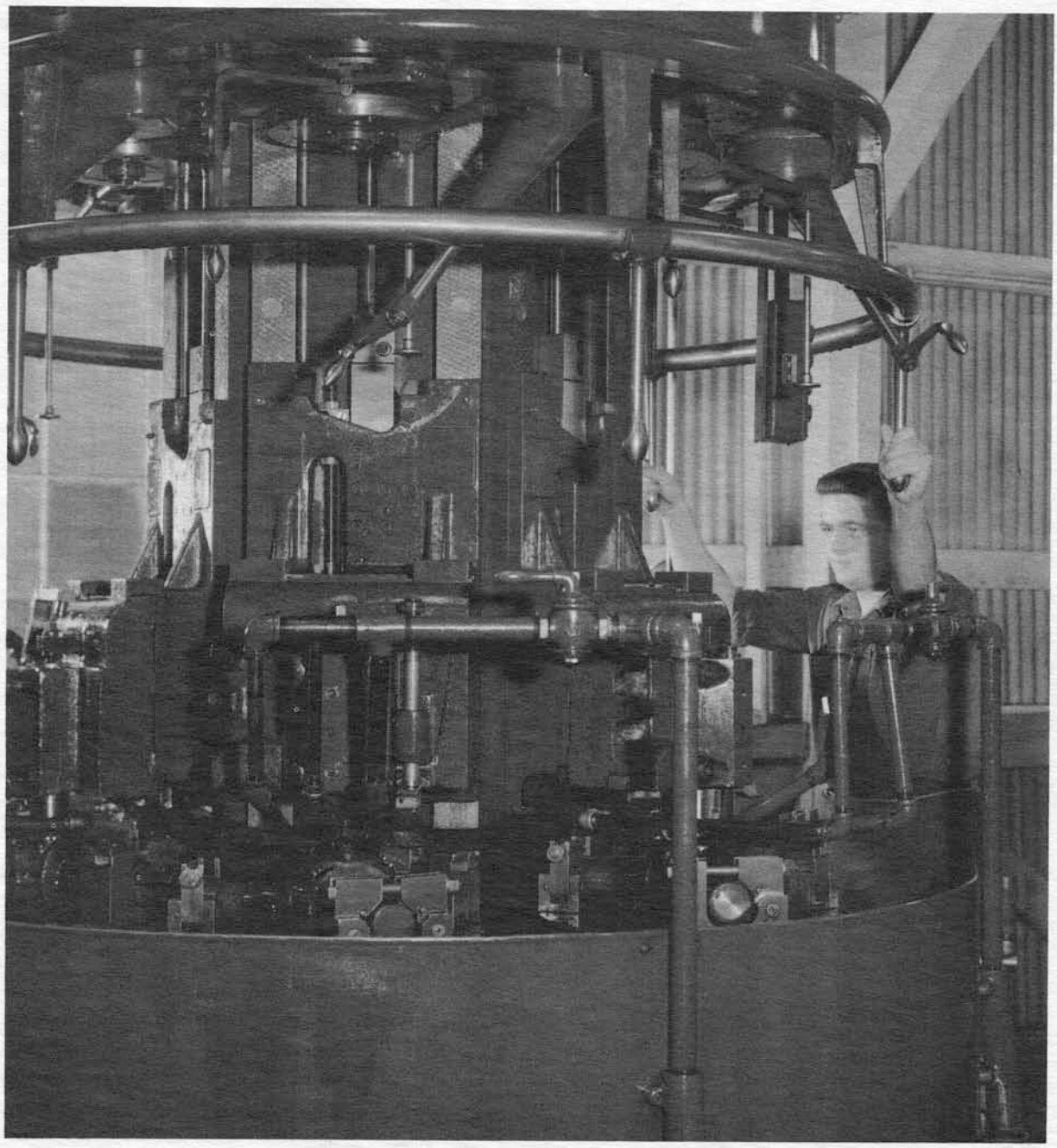

MACHINING CONE SEAT AND ONE END OF HUB OF SPIDER ON BULLARD 16-IN., 6-SPINDLE MULTI-AU-MATIC MACHINE

HISTORY OF THE CONTRACTS - (Con't.)

Fifth Contract. On September 24, 1943, the prime contractor made inquiries with regard to still further production of the standard size Spiders and Barrels. No formal quotations were made, although the Company advised -- under date of September 28 -- that it was arranging a schedule of production for 1944.

A contract was received by the Company on December 17, 1943. It called for 22,760 Spiders and 20,420 Barrels, with shipments of 700 Spiders to be made in November, 1943, and 2,800 Spiders and 1,320 Barrels in December, 1943. Subsequent shipments were to be:-

Month - 1944	Spiders	Barrels
January	2,800	2,825
February	2,800	2,825
March	2,800	2,825
April	2,800	2,785
May	2,750	2,715
June	2,675	2,525
July	2,635	2,600

The first shipments under this contract were not made until March 7, 1944, however, production being dovetailed in with the completion of items under the Fourth Contract.

Then -- on November 15, 1944 -- the schedule of shipments was revised, and an increased number of each part was ordered, the total now being set at 28,256 Spiders and 24,819 Barrels, with final shipments to be made in December, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS - (Con't.)

As of December 31, 1944, the number of Spiders shipped by the Company on this contract had reached a total of 28,946, or 690 more than called for. The number of Barrels shipped was in the amount of 26,335, or 1,516 more than called for under the contract.

(In this connection it should be stated that at the end of the Fourth Contract -- March 31, 1944 -- there had been overage shipments of both Spiders and Barrels, which overages were applied to the number ordered on the Fifth Contract.)

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

In order that these overage shipments might be caught up with, and not carried on to future contracts, the Company -- under date of January 10, 1945, wrote to the prime contractor suggesting that the Fifth Contract might be increased to take in the latest overage shipments of 690 Spiders and 1,516 Barrels, and be terminated as of December 31, 1944.

Under date of May 21, 1945, the prime contractor notified the Company that its records showed that a total of 93,331 standard Spiders had been ordered on the first five contracts, and that a total of 94,021 had been received by it. Also, that a total of 89,894 Barrels had been ordered on the five contracts and that 91,410 had been received. It was agreed that the procedure recommended by the Company as to termination of the Fifth Contract to include these overages would be followed, so that books would balance.

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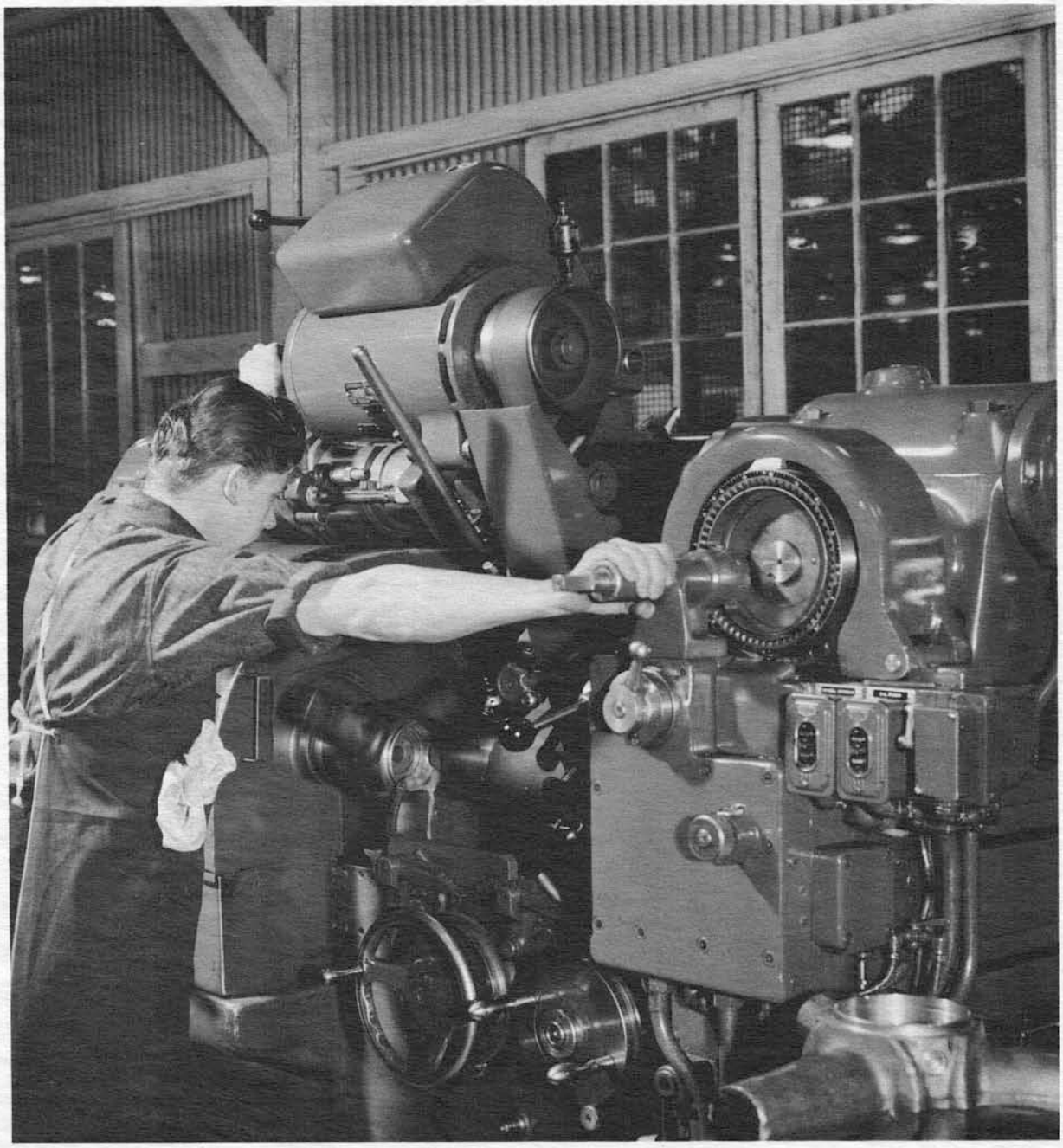

GRINDING 15-DEG. AND 30-DEG. CONE SEATS ON A BRYANT 2-SPINDLE INTERNAL GRINDER

HISTORY OF THE CONTRACTS - (Con't.)

Sixth Contract. The Company was advised -- on January 14, 1943 -- that the prime contractor's future production of propellers would require changes in the size and design of the Spiders and Barrels, and that this, in turn, would necessitate some changes in tooling by the Company. The necessary changes and the time required to make them were to be determined by the Company and the prime contractor was to be advised. On April 22, 1943, the Company again was asked as to the time required for the changeover in production, and the estimated cost. A third request was received by the Company on August 5, 1943, and the information was forwarded on August 20.

On September 5, the Company was advised that the production schedule for the new -- and larger -- type of Spider and Barrel was confirmed, and that a contract was in preparation covering the prime contractor's requirements for Part # 55,099 (larger Spider) and Part # 56,348 (larger Barrel). The contracts were submitted to the Company on December 1, 1943, and were executed on December 17. They called for 1,825 Spiders and 2,050 Barrels, with deliveries of the Barrel during March, June and December, 1944, and of the Spider during June and September, 1944. First delivery was to be made on March 14, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS - (Con't.)

A supplement to this contract was issued on June 20, 1944, setting up a schedule to be completed in December. Up to December 30, 1944, deliveries were in the amount of 1,577 Spiders and 2,042 Barrels. Under the agreement reached with the prime contractor, this contract was closed out in the above amounts. The production of the large size Spiders and Barrels went forward simultaneously with the production of the standard size, the work being described in a following section of this report.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Seventh Contract. Following telephone conversations during August and the early part of September, 1944, the prime contractor awarded the Company another contract for further production of the small, or standard, size Spiders and Barrels, the contract being received by the Company under date of December 1, 1944. It called for a total of 4,593 each of the two pieces, with deliveries to begin in January, 1945, in the number of 1,293 each, to be followed by 1,300 in February; 900 in March; 650 in April and 450 of each piece in May, 1945.

The first shipments of each piece went forward on January 10, 1945, and continued on schedule until February 27, 1945. On that date the order for the Spiders was increased to a total of 12,952, while the number of Barrels ordered was increased to a total of 17,771.

MILLING FLANGE DIAMETERS ON THE ARMS OF THE SPIDER ON A SUNSTRAND 2-SPINDLE PLANETARY

HISTORY OF THE CONTRACTS - (Con't.)

Another increase in each piece was ordered on March 31, and still another increase under date of May 17, 1945. Then, on June 22, reductions in the total number of each piece were ordered, while on August 14, 1945, the order for Spiders stood at 13,368, and for Barrels, at 15,107. Schedules had been revised each time a change-order was received.

Then, on August 17, 1945 -- three days following Japan's capitulation -- the Seventh Contract was ordered terminated, with shipments being accepted up to August 30. The contract then was closed out in the amount of 9,461 Spiders and 8,978 Barrels.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

- - -

Eighth Contract. Also on December 1, 1944, the Company was in receipt of this contract calling for 2,250 each of the large size Spiders and Barrels, with shipments to start in January, 1945, and run through May, that year. The first shipment of these parts also went forward on January 10.

As in the case of the Seventh Contract, increases in the number of pieces were ordered on various dates, the first -- on February 27 -- calling for a new total of 5,424 Spiders and 4,922 Barrels. On March 24, the number was

HISTORY OF THE CONTRACTS - (Con't.)

increased to 8,357 Spiders and 8,019 Barrels. On April 2, the number of pieces of each part was cut back. This was followed by another reduction in the number of the Spiders on April 3, and on April 11, by still another reduction in the Spiders. On May 21, there was a request for an increase in the number of each piece, with still a further increase ordered under date of June 30. On August 10, the order for Barrels -- which stood at 9,106 -- was reduced to 8,204, and on August 11, the Spiders -- which stood at 9,024 -- were reduced in number to 8,588. This was followed by a termination of the contract -- on August 17, 1945 -- in entirety, with shipments being accepted of each part up until August 30. On that date the Spiders were closed out in the amount of 1,994 pieces, while Barrels were closed out at 1,639 pieces.

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(A table showing the total number of Spiders and Barrels shipped by the Company to this, and also to other facilities, is to be found on Page 60 of this report.)

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Orders Received From:

Remington Rand, Inc.,
Propeller Division,
Johnson City, N. Y.

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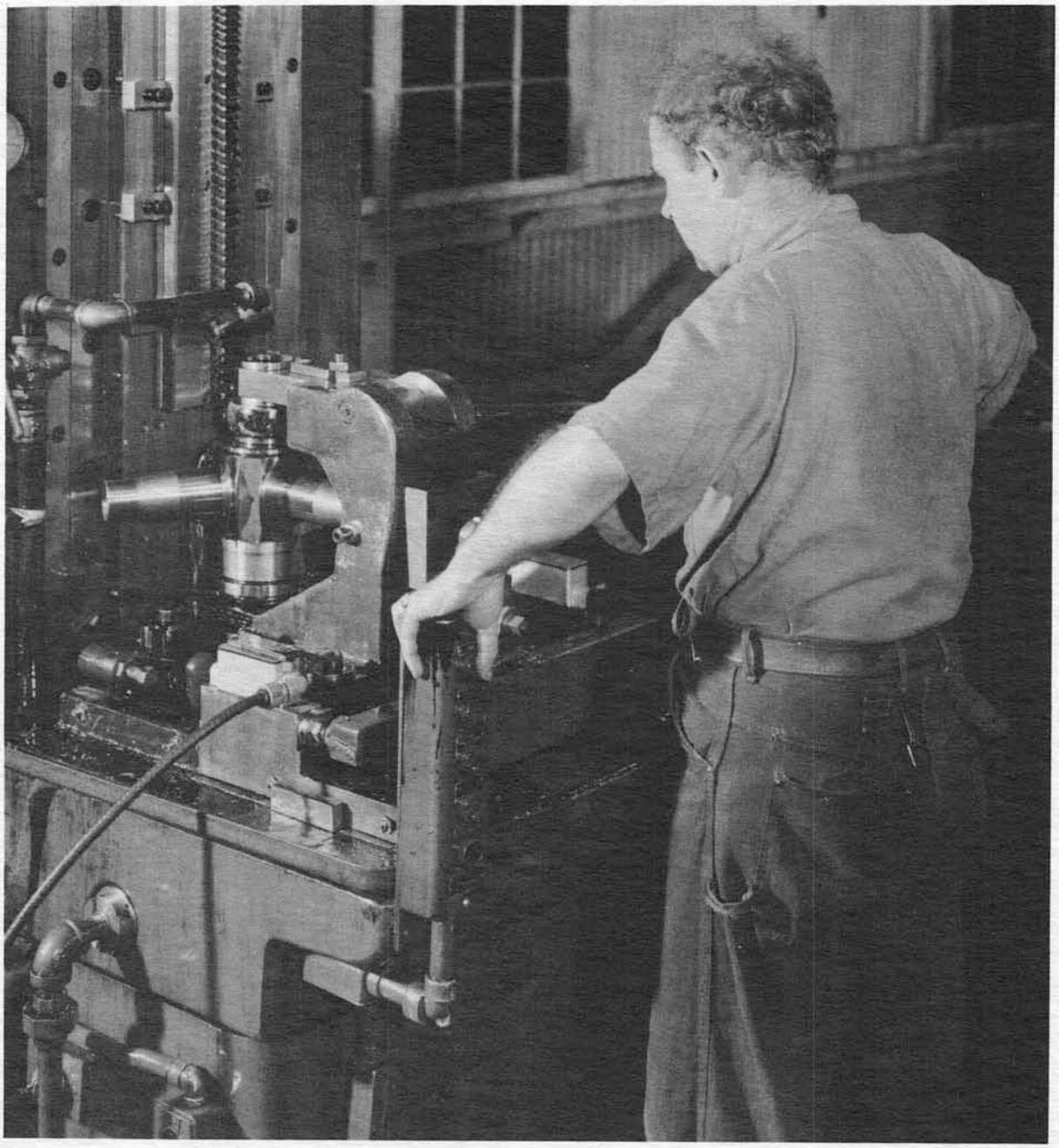
First Contract. While the Company was manufacturing the small, or standard-size, Spiders and Barrels for the Hamilton Standard Propeller Division, United Aircraft Corporation, it received an inquiry regarding production of similar items for Remington Rand, Inc., Propeller Division, from that Company. The forgings were to be supplied and the Company was to machine them only. This inquiry was received on November 2, 1942. A quotation was forwarded on November 18, and two days later a purchase order for 6,500 each of the two parts, was received by the Company.

The schedule of shipments called for first deliveries in December in the amount of 500 of each of the parts. The same number of each part was to be shipped in each of the three succeeding months. In April and May, 750 of each part were to be shipped, with the number upped to 1,000 of each in each of the months of June, July and August, 1943. The first shipments did not go forward until February 5, 1943, however.

On July 26, 1943, a supplement to this first order was received increasing the number of each part to 1,300, or a total of 7,800. Shipments were to be determined from time to time by the quantities of forgings supplied the Company.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY



FINISH BROACHING 1¼-IN. SLOTS ON LA POINTE 30-IN. VERTICAL BROACHING MACHINE

REMINGTON RAND CONTRACTS - (Con't.)

The last shipment under this first order was not made until June 24, 1944, some ten months after the date set in the original schedule. The delays in deliveries were occasioned by failure of the prime contractor to furnish the necessary forgings.

The actual shipments made on this first order were in the amount of 7,903 pieces each of the Spiders and the Barrels. The overages were applied to the next order.

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Second Contract. On October 25, 1943, the Company suggested to Remington Rand, Inc., that it determine its requirements for the first half of 1944. This resulted -- on December 2, 1943 -- in receipt of purchase orders for 3,000 each of the Spiders and Barrels, with deliveries to be made at the rate of 500 of each part during each of the next six months. The numbers later were increased for each part, the total Spiders being put at 3,052, and Barrels at 3,025.

The first deliveries were not made until March 17, 1944, the delays again being due to the inability of the prime contract to supply forgings in sufficient quantity.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

REMINGTON RAND CONTRACTS - (Con't.)

Because of this continued shortage of forgings, it was on September 15, 1944, that the prime contractor notified the Company that it would cancel out its order in the number of Spiders and Barrels already delivered and in process. The last shipment of Spiders went forward on September 26, this order being closed out in the amount of 3,047 pieces. The last shipment of Barrels went forward on November 11, 1944, the order being completed in the amount of 3,022 pieces.

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Third Contract. Again -- in mid-1944 -- the Company queried the prime contractor as to its requirements for the early months of 1945, and -- after several letters and telephone conversations -- purchase orders for 2,000 each of the standard-size Spiders and Barrels were received. This was on October 31, 1944. The parts were to be delivered at the rate of 1,000 each, in November and December, 1944. The first shipment of Spiders went forward on November 11, and of the Barrels on November 17, 1944.

The last shipments were made on March 17, 1945, the Spiders being closed out at 781 pieces, and the Barrels at 764 pieces. The reason for the cancellation -- received April 25, 1945 -- was that the prime contractor could not supply additional forgings.

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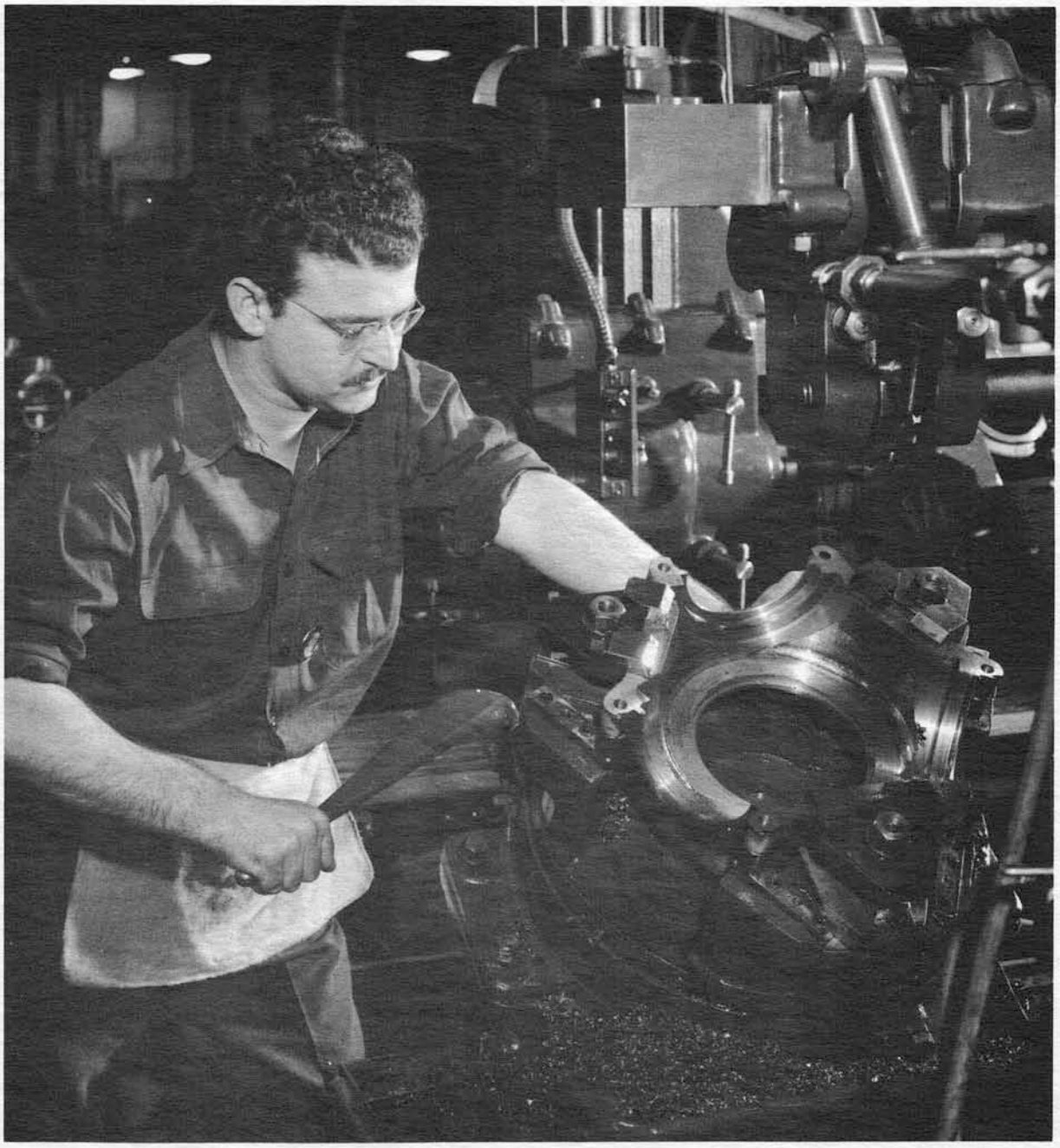
PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY



ROUGH MACHINING 3-IN. RADIUS ON THE INTERIOR OF THE BARREL—ON SUNSTRAND MILLING MACHINE

REMINGTON RAND CONTRACTS - (Con't.)

Special Order. Late in November, 1944, the Company was asked by Remington Rand, Inc., if it would machine some forgings for Barrels for De Haviland propellers, which could be received in quantity on a Lend-Lease basis from Great Britain. These forgings were heavier than the forgings for the Hamilton Standard Propellers, having from 1/16" to 9/16" excess stock in various areas. A change of fixtures would be required and a new cutter would have to be made to handle this production.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

> The Company agreed to handle the first two De Haviland forgings and to determine the price that would have to be charged for the work. The first two were machined and the Company quoted a price on December 20, 1944. Then -- on January 29, 1945 -- Remington Rand, Inc., increased the amount of its purchase order from the two original pilot pieces, to a total of 309 Barrels.

The Company made its first shipment of 16 of the De Haviland Barrels on March 31, following with a shipment of 87 on April 30. Thirty-six were shipped in May, and 100 in June. Thirty-three went forward in July. Five were shipped August 18, 1945, and three more on August 24, the order being cancelled in the amount of the 280 pieces shipped up to that date.

* * *

Orders Received From:

Nash-Kelvinator Corporation
Propeller Division
Lansing, Mich.

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During November, 1944, the Union Switch & Signal Company received a telephone inquiry from the Nash-Kelvinator Corporation, Propeller Division, Lansing, Mich., regarding production of the large-sized Spiders and Barrels. A quotation was made November 20, and on December 7, a purchase order, covering 1,220 of each of the parts, was received.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

> The schedule called for delivery of 250 of each of the parts up to February 15, 1945, then 465 of each part in the period from February 15 to March 15, with delivery of the final 505 pieces of each part between March 15, and March 31, 1945.

Due to non-receipt of the forgings from which the Spider and the Barrel were machined, the first shipment of the Spiders was not made until February 28, and of the Barrel until March 15. In the meantime -- on January 1, 1945 -- the order for Spiders had been increased to a total of 1,350, then later to 3,905. The order for the Barrels was increased to 3,950 on January 1, and on June 21, was decreased to 2,430. Shipments were going forward when -- on August 22, 1945 -- the Company was notified to stop work and to close out the two pieces in the amounts shipped to date. Up to August 18, a total of 2,446

NASH-KELVINATOR ORDERS - (Con't.)

Spiders had gone forward, while on August 22, a last shipment of Barrels was made, bringing total shipments of this piece up to 1,754. There also was a total of 968 of the Barrel piece in process on this date. An adjustment on this was arranged.

- - -

On May 10, 1945, the Company was in receipt of purchase orders from Nash-Kelvinator, covering the machining of 8,075 Spiders and 8,075 Barrels, these to be shipped following completion of the first order. However -- on June 18 and 19 -- these orders were cancelled.

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

FINISH GRINDING 3-IN. RADIUS IN BARREL ON A HEALD NO. 50 OSCILLATING GRINDER

RECAPITULATION OF PRODUCTION

In the table below is given the numbers of Spiders and Barrels -- both the standard (S), and the large (L), size -- produced by the Company under all orders from the three prime contractors, together with a notation of the number of De Haviland Barrels machined for Remington Rand, Inc., Propeller Division, under special order:-

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Part	Total Number of Pieces Machined and Shipped					Totals:
	(S)	(L)	(S)	(L)		
Hamilton Standard Propellers:						
Spider	103,482	3,571	- - - -	- - -	- -	107,053
Barrel	- - - -	- - -	100,388	3,681	- -	104,069
Remington Rand, Inc.:						
Spider	11,628	- - -	- - - -	- - -	- -	11,628
Barrel	- - - -	- - -	11,586	- - -	- -	11,586
De Haviland Barrel - (Special order)-				- - -	280	280
Nash-Kelvinator Corp.:						
Spider	- - - -	2,446	- - - -	- - -	- -	2,446
Barrel	- - - -	- - -	- - - -	1,754	- -	1,754
Totals:	115,110	6,017	111,974	5,435	280	238,816

* * *

MANUFACTURING OPERATIONS - (Spiders):

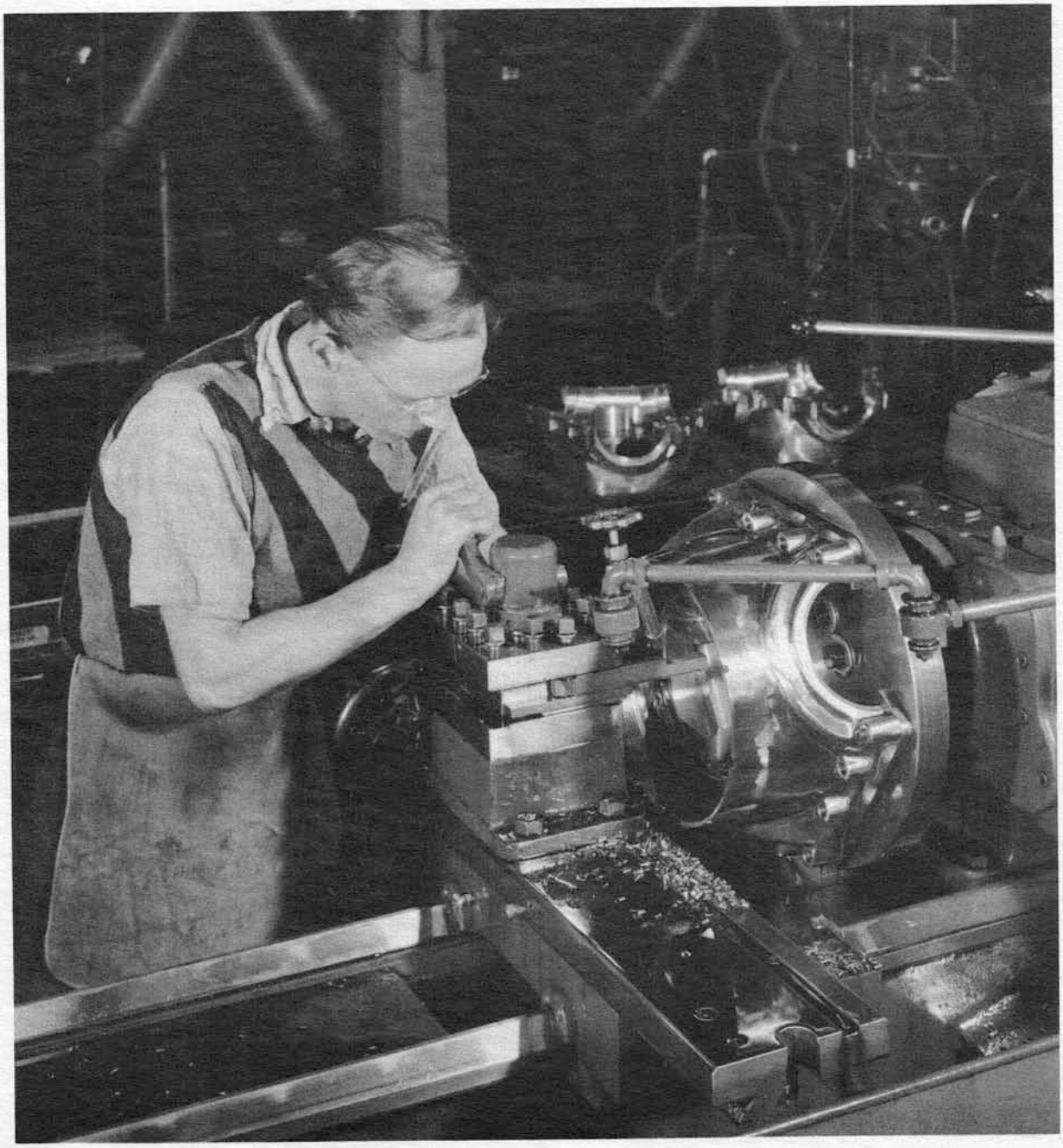
Two types and two sizes of Spiders were manufactured by the Company. These were # 53,644 -- (small, or standard size) -- and the large size, which had the number # 55,099, assigned to it. With but three exceptions the two types were subject to the same manufacturing operations. The three additional operations, described below, are on # 55,099.

The general operations consist of converting a rough steel forging of AMS-6415 steel -- (a cobalt nickel steel) -- with a heat treatment specification of HSP #10 -- (from 390 to 415 Brinell hardness) -- into a hub Spider for a hydromatic propeller for airplanes. The piece carried a mirror finish on many of the dimensions, and tolerances had to be rigidly observed and maintained. Some 48 gage inspections were required on each Spider, each piece being checked after a sequence of operations, before being passed on to the next series of operations.

Three balance tests were given each Spider before final inspection by the Company and shipment of the piece to the prime contractor. The Spider had to balance in all positions about the cone seat axis.

On the small Spider the overall dimension was 7 7/8". On the large Spider this dimension was 8 15/16". Three Micarta block seats, each opposite to an arm of the Spider were broached. The width of

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY



BORING HOLE IN THE DOME SHELF OF THE BARREL

MANUFACTURING OPERATIONS - (Spider) - (Con't.)

the seat on the small Spider was 1¼". On the large Spider the width was 1 3/4". Each seat slot has to be central with the arms within plus/minus .005" -- (or .010", depending upon the size of the Spider).

On the small Spider the bore of the hub was machined to a diameter of 3.562" -- plus .005"/minus .002" -- while the splines broached in the hub were for a #50 SAE (key) tooth. On the large Spider the hub diameter was 4.4464" -- plus .005"/minus .002" -- the splines being broached for a #60 SAE (involute form) tooth.

Fourteen small slots, and one large slot -- cut on the basis of 16 equally spaced slots and providing 15 teeth -- were cut in the hub of the small Spider. On the large Spider there were 31 teeth, with one omitted, cut on the basis of 32 teeth.

On both sizes of the Spider the large spline has to be central with any one of the Spider's three arms.

In no case did any of the gage inspections on the two sizes of the Spider permit of tolerances greater than plus/minus .005". Many of the tolerances had to be held to .002", while on two inspections the allowance was held to plus .000"/minus .0005".

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Spiders) - (Con't.)

Some 34 major operations were performed on the small Spider, and approximately 37 on the large Spider. These run as given below, the extra operations on the larger forging being marked with an asterisk - (*):-

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Cut tang from end of one arm; machine 30° end on a Bullard six-station Mult-au-matic -- (this includes rough boring of 5 19/32", and 4 27/32" diameters, and the 30° cone seat); finish face end 2.322" to the centerline and rough drill through and finish bore 3.562" -- (or 4.4464") -- hole and finish bore; semi-finish 5 19/32" diameter bore and 30° cone seat, leaving .004" for finish; finish bore 4 27/32" diameter to blue-print; rough turn 5 3/4" diameter to 5.790" -- plus .010" minus .000" -- by 1.16" deep, and form 1/8" radius.

Bore and turn 15° end, facing end to 8.9625" -- plus .000"/minus .005" -- overall; rough and finish spline broach and burr splines; bond and stamp; mill 30° cone seat counterbore; (*) mill 3/16" snap ring groove; grind 30° and 15° ends; drill, bore and turn arms, and face shimface; mill sides of flange; rough broach three 1.750" -- (or 1.250") -- Micarta block seats; cut back centers on Micarta block seats; polish arm bores; re-cut arm and back centers; check 120° angle of arm centers; check 90° angle of arm centers.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

FINISH GRINDING INSIDE RADII OF THE BARREL WITH KELLERFLEX GRINDING MACHINES

MANUFACTURING OPERATIONS - (Spiders) - (Con't.)

Re-cut arm diameters and shimface; rough grind large arm bearing; rough grind small arm bearing; finish broach 1.750" (or 1.250") slots; turn outside diameter on 30° and 15° and grind outside diameter on these ends; (*) mill three 3/8" slots on 30° end; file 1/32" radius on ends of arms; broach 1/8" x 45° angle on three Micarta block seats at ends.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Also: Drill 11/64" -- (oil) -- holes from base of block seats into arm bores; Kellerflex and break all small corners; finish grind large arm bearings and shimface; finish grind small arm bearings; polish large and small arm bearings; burr and touch up; balance Spider and grind 7° 40' taper on arms, 1 3/8" from end of each arm and form ½" radius; (*) grind 15° outer angle and blend with ½" radius; finish grind 30° and 15° cone seats; check balance and Kellerflex arms to balance; mirror finish 30° and 15° cone seats, and final check balance of Spider.

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On both sizes of Spider the axes of the arms had to be at right angles to the cone seat axis within .002" in 12", and each arm axis had to pass within .002" of the cone seat axis and of all other arm axes. The tapers of the 15° cone seats had to be concentric with the spline within .001".

MANUFACTURING OPERATIONS - (Spiders) - (Con't.)

When a rough forging was received it carried -- on the arm bearing the tang -- the heat code number as well as the Government acceptance number. These numbers had to be transferred by stamping to each Spider, and the work and inspection ticket that accompanied each piece through the various operations also had to carry the corresponding heat code and acceptance number. Omission of these numbers from the finished piece was a cause for rejection by the prime contractors.

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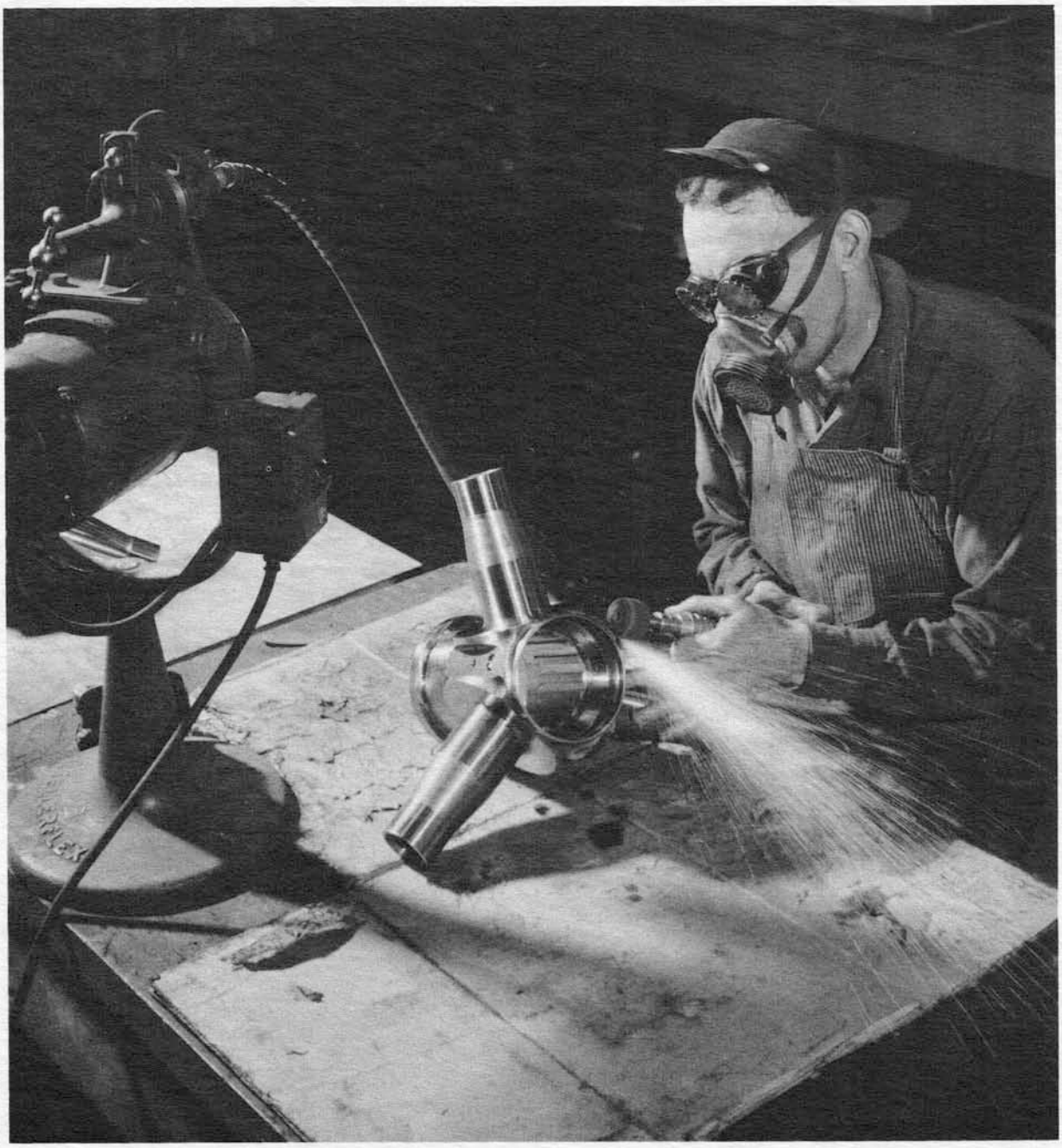
PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Barrels):

As in the case of the Spiders, the Barrel -- (or housing of the hub Spider) -- was manufactured in two sizes, the small, or standard, Barrel being designated as # 56,342, and the large, as # 56,348. The machining operations on both sizes were identical. The only variation was in certain dimensions. There were two sections to each Barrel -- front half and rear half. Operations were as exacting as in the case of the Spider. The front half had certain excess material cut from it after which twelve bolt holes were drilled, four to each arm section. The bolt lugs were milled and countersunk, and a thread hole was bored. Certain dimensions were ground in this first operation, while the flange face also was ground.



GRINDING RADII ON THE SPIDER
WITH KELLERFLEX POLISHING MACHINE

MANUFACTURING OPERATIONS - (Barrels) - (Con't.)

Excess material also was removed from the rear half of the Barrel; bolt holes were drilled and the hub diameter bored. The bolt holes then were spot-faced and countersunk and the contour was milled.

The halves then were bolted together, the Barrel thus being mated and worked as one piece, each half being stamped with identical piece numbers. Succeeding operations were performed with each half mating. A total of some 46 operations -- including several inspections -- followed. These included:-

Milling ends of arm holes; boring arm holes; forming around the bolt bosses; form-milling inside 5° on front half; milling 3" radius on both halves; milling nine 5/16" slots on the front half; rough grinding contour and polishing; Kellerflex grinding; finish grinding and parting; milling gasket groove; grinding 10 3/16" and 10.375" dimensions; milling Acme thread -- (8 threads to the inch and square to within .003") -- and blencing the ends; drilling and reaming three .3475" holes.

Also: form-grinding the inside of the flange and grinding the rear bore; grinding a 3" radius; completing grinding of arm bores and lip; grinding blade bore and angle; grinding packing bore; boring and fin-

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Barrels) - (Con't.)

ishing 7.760" diameter hole; forming six corners on each parting face on the front and rear halves; reaming and countersinking three .372" holes on the front half; drilling, countersinking and tapping eight $\frac{1}{4}$-28 NF2 holes.

Then followed: Grinding of all radii on each half; blending of the arm bores when halves were mated; balancing by halves and touching up the Barrel for balance, also by halves; spot-facing rear half only; burring and filing of all sharp edges; hand reaming the three .372" holes on the front half; etching numbers "1", "2" and "3" on front half to correspond to numbers on Spider arms; inspection of all dimensions; polishing between lugs, by halves; re-check of balance, by halves; blending profile all over when mated, and final visual inspection. The barrel then was packed for shipment.

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Tolerances on both size Barrels were held -- in most instances -- to plus/minus .005", but in some instances the variations allowed were given as plus/minus .002"; plus .002"/minus .000", and plus .000"/minus .001".

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Barrels) - (Con't.)

Some of the differences in dimensions were:-

	Barrel Number:	
	56,342	56,348
Center line to inside wall	5.250"	5.688"
Center line to inside of arm flange	5.562"	5.968"
Center line to wall at 5° angle	5 11/32"	5 9/16"
Center line to end of radius on 5° angle	4 25/32"	5 3/16"
Outside diameter of bore -- (rear half)	6 11/16"	7 1/2"
Inside diameter of bore -- (rear half)	5.547"	6.344"

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

* * *

MANUFACTURING DIFFICULTIES:

The utmost precision was required in the machining of both the Spiders and the Barrels. The techniques employed by the Company in production were aided in no small measure by reason of the fact that machines -- especially designed and made for particular operations -- were purchased and installed. Each of these special machines performed certain operations in one manufacturing cycle. This especially was true in the manufacture of the Spiders.

CHECKING ANGULAR RELATION
OF THE ARM BORES OF THE BARREL

MANUFACTURING DIFFICULTIES - (Con't.)

The use of Bullard, six-station, Mult-au-matics, with five working stations and one loading station, permitted of more than one operation with but one set-up. Each operation was performed and the piece passed along for the next -- automatically, precisely and efficiently. Each piece was checked at the conclusion of the cycle and then was passed along to other machines right down the production line. There was no back-tracking but, instead, a steady sequence in operations until the piece was ready for shipment.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

In the manufacture of the large size Spider, however, there was one instance of back tracking. This was when the 3/16" groove for a snap ring was milled. The outside diameter on the 30° end was ground and the piece then returned for the milling of the groove. This was necessitated because a wall of only about .020" was left between the bottom of the undercut and the outside diameter. If the groove was milled before the outside diameter was ground, there was danger of burning the undercut by the heat of the grinding. On the small Spider there was a thicker wall, so that the outside diameter was ground after the groove was milled.

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All of the work on the outside of the Barrels was performed by hand grinding. This required the utmost skill and precision. The arms of the Spider also were ground. If the grinding was accelerated beyond a certain point, heat cracks were apt to occur, and the piece would have to be scrapped. During the first eighteen months of production, rejections in general ran to about 18%, against a scrap allowance specified in the contracts, of 10%. Continued experience in production, coupled with training of personnel, led to a reduction in the percentage of scrap to well below the figure allowed.

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The care and skill required in production of the two parts is suggested by the fact that both were in work over a period of many hours, the individual Spider taking about a day, and the average Barrel covering a period of at least twice that time. Some 142 men -- and their machines -- performed the various operations on the Barrel, and as many as fifty men -- and machines -- took part in manufacturing the Spider. Obviously, even the slightest carelessness along the production line could ruin the labor of many other workers extending over hours of time.

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The machineability of the steel, used in both the Spider and the Barrel, constituted an important and continuing problem. The steel used was one of the most difficult to machine successfully, and the wear on each cutting or grinding tool was carefully watched, and in many instances anticipated. The special department in which the work on the Spiders and Barrels was handled set up its own tool and repair department, and also had its own crew of lubricating specialists, the oiling of the machines being left to this special crew.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Engineers of the companies manufacturing the special machines used in producing the Spiders and Barrels helped to install them. These engineers also aided in educating the men selected for the operation of these machines, and cooperated with Company engineers until familiarity with the various operations was achieved.

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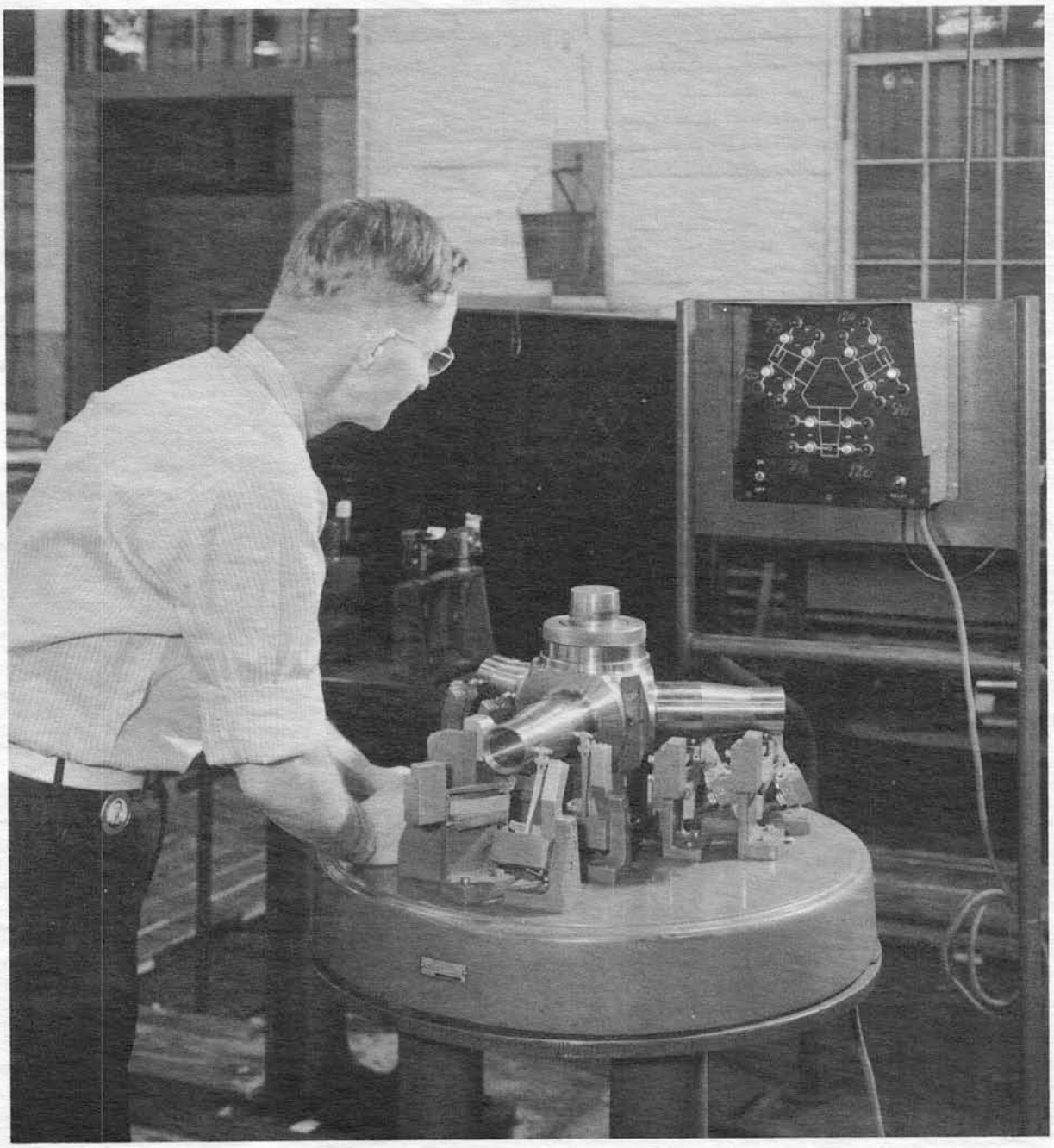
Procurement of the needed machines was difficult and time-consuming. Eighty percent of the equipment needed was to be new and -- as stated previously -- most of it specially built to perform specific operations. The Company maintained a member of its Purchasing Department in the field to expedite procurement. In this way one machine of each type needed was obtained as quickly as possible. It would be installed and used to instruct the new production force, in advance of



CHECKING 120-DEG. AND 90-DEG. POSITION OF THE ARMS OF THE SPIDER

the receipt of similar equipment. The same procedure was followed in regard to jigs and fixtures. The prime contractor was asked to cooperate to the extent of providing the Spiders and the Barrels machined up to the point where the Company could take over and complete production. This was when the work first was started.

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One of the initial steps taken by the Company when it took on the contract was to send a group of selected men to the plant of the prime contractor, there to observe manufacturing operations. These men included grinding experts and operators; a milling machine operator, a boring mill operator, an apprentice metal pattern worker, and a man who had been suggested for the position of chief inspector. These men remained at the plant of the prime contractor for various periods of time. On their return to the Company's plant they began the training of personnel for production.

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The total number of employes in the special department assigned to the work -- at peak production -- was approximately 825. This included some 650 production workers; 50 inspectors; 25 supervisors; 25 tool grinders; 25 laborers, together with machine repairmen, oilers, packers and miscellaneous workers.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

This group -- literally -- had been picked from the ranks of unskilled labor. With a nucleus of trained men, the production line was built from applicants for jobs whose previous work had been that of garagemen, auto repairmen, attorneys, dentists, undertakers, school teachers, ball players, insurance agents, musicians, barbers, etc. They were men who wanted jobs in a war plant and who applied for work on their own volition. No women were employed in the department.

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Turnover of labor -- exclusive of the demands of Selective Service -- was held at a remarkable low figure, after the preliminary "weeding out" of personnel who, experience and trial revealed, obviously were unfitted for the work.

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Every effort was made to fit the man to the job and, at the same time, to fit the job to the man. Following the preliminary interview by the employment department, the new worker was assigned to a certain machine, or to a certain task, and there -- under an experienced worker -- he was given a tryout. When thoroughly familiar with his job he was left more and more "on his own." If he proved adept and quick to learn, he then was made familiar with other operations. In this way some of the supervisory personnel was secured, these men being assigned certain sections for which they were made responsible.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

The employes in the special department assigned to the work of producing the Spiders and Barrels evinced a pride in their work; in the exacting requirements for the production of these vital pieces used by the air forces of the nation, and in their achievement in producing items that were considered to be among the most intricately machined items of war materiel manufactured in the United States during World War II.

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THE 20 MM. OERLIKON H. E., A-A SHELL

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First Produced for British, Later for United States Navy -- Procurement of Steel and Inspection Changes Slowed Production but Company Met all Schedules Over Which It Had Any Control -- More than 35,000,000 Produced and Shipped by Company in Forty-four Months -- Inexperienced Crews Trained for Production

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Inspection of screw machine facilities at the plant of The Union Switch & Signal Company late in 1940 by representatives of the British Purchasing Commission led to an order -- on January 15, 1941 -- for a total of 1,250,000 pieces of the item known as the 20 MM. Oerlikon, High Explosive, Anti-Aircraft Shell -- then used by the British in certain of their weapons. When some 130,000 shells had been shipped, the contract was cancelled by the British. The United States Navy, operating under Lend-Lease, took over the contract, increasing it to a total of 1,700,000 shells, in addition to the 130,000 already produced for the British.

The Company, which had sub-contracted production of a certain number of the shells to The Westinghouse Air Brake Company, continued to supply shells of the British pattern, but later changed over to production of a modification of the shell, known as 20 MM. Anti-Aircraft Projectile, Mark III.

From the time of the British contract, up to April 15, 1945, the Company shipped a total of 35,165,210 shells and also supplied an additional 1,564,790 pieces produced by the Westinghouse Air Brake Company under sub-contracts, or a total of 36,730,000 shells in all.

Despite difficulty -- from time to time -- with the steel from which the shell was machined, and at certain times with changes in the inspection methods, every schedule over which the Company had any control was met, or exceeded.

As was the case with all previous -- and subsequent -- production of war materiel by the Company, manufacturing space was found within the existing plant. Some 10,000 square feet of former storage space was gradually allocated to production of the 20 MM. H. E. Shell. From time to time there was a re-arrangement of machines and other facilities for the purpose of stream-lining the production line, the methods were introduced -- even as late as December, 1944 -- leading to the holding down of scrap and to increasing production.

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When the British contract was taken on, certain operations on the shell had to be performed at the plant of the Westinghouse Air Brake Company, until certain machines could be procured and installed by the Company. The production of 900,000 of the initial order of 1,250,000 shells, also was sub-contracted to WABCO. Later on additional amounts were turned over. The Company eventually assumed all production on its own contracts and -- on May 5, 1943 -- sub-contracted to the Westinghouse Air Brake Company for the production of 14,400,000 shells, the prime contract for which had been awarded to WABCO. In mid-1944 the Company received a direct order from the United States Navy for an additional 14,400,000 shells. This order was cut back early in 1945, and eventually was terminated in the amount of 9,500,000 pieces.

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Plant capacity for production, at the time the British contract was assumed, was 35,000 shells a month. With the acquisition of additional machinery, capacity increased until the special department assigned to this item, could turn out 1,350,000 shells monthly. This rate of production never was reached on any one order, however, the Navy rigidly allocating production to not more than 1,200,000 shells monthly.

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The department, which during peak production had 130 machine operators, and 42 checkers, working a triple-turn, seven-day week, gradually was built up around a nucleus of experienced help. With the exception of a few experienced machinists and grinders, all employes in the Shell Department were new, and without previous shop experience. From the start, in building up the department, the Company co-operated closely with the Pittsburgh Board of Eduction, and recruited its help from the students taking the vocational courses in the Pittsburgh schools. Middle-aged men were given preference in employment, and women were chosen to perform the inspection and checking operations.

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It is to the credit of the Company and the personnel of the Shell Department that there never was a reported instance of failure in a firing test, of any shell supplied by the Company.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

With the entrance of the United States into the war, approximately one-quarter of the Department's original group of machine operators were lost to the Company through the demands of Selective Service, or through voluntary enlistment. There was a continuing large turnover, for the same reasons, throughout most of the life of the contracts.

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HISTORY OF THE CONTRACTS:

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

First Order. Negotiations for production of the 20 MM. Oerlikon, High Explosive, Anti-Aircraft, Shell, were instituted with visits to the Company's plant by representatives of the British Purchasing Commission between December 2, and 19, 1940. These negotiations were conducted both with the Company and with the Westinghouse Air Brake Company. Upon agreement -- and for policy reasons -- the contract for the first production of the shells was awarded the Company. The quotations were made January 11, 1941, and a contract for 1,250,000 shells, was received from the British Purchasing Commission on January 15.

Under date of March 25, the Company advised the British Purchasing Commission that production of 900,000 of the shells would be sub-contracted to the Westinghouse Air Brake Company, with production of 350,000 at the Company's plant. Shipments would begin in April and conclude in March, 1942.

HISTORY OF THE CONTRACTS - (Con't.)

The first shipment -- of four test pieces -- went forward on April 3, 1941, and was followed by shipment of 5,000 pieces on April 30. On that date the British Purchasing Commission gave notice that it was cancelling the contract in its behalf as it was to be taken over by the United States Government, under Lend-Lease, but that it would accept shipment of shells up to June 16, 1941. The shells -- which were being shipped to British-designated loading stations -- were being produced by WABCO, and a total of 130,000 were shipped up to June 16.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

As of June 17 the United States assumed the contract. Under an order -- (LL-87333 -- US&S GO 465000) -- the number of shells was increased to a total of 1,700,000. In addition the amount of the 130,000 already shipped was added to the order, making it 1,830,000 in all.

Additional production was sub-contracted to WABCO, and, at the conclusion of this contract -- on March 21, 1942 -- the shipment record stood as follows:-

Shipped by:	From:	To:	Amount:
WABCO	4-30-41	2-6-42	1,564,790
US&S	7-25-41	3-21-42	265,210
Total number shipped			1,830,000

HISTORY OF THE CONTRACTS - (Con't.)

In addition, on this first contract, WABCO performed the centerless grinding, and first and second automatic operations on 106,628 shells for the Company; did the centerless grinding alone on 191,575 shells, and machined the rotating bands and base ends of 391,100 shells. Some of these shells were to be used in filling the first order, others on subsequent orders.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Second Order. On April 11, 1941, the Navy made inquiry regarding the production of an additional number of shells, of the Mark III type. Quotation was made on May 8, and the Company received notice on May 20, it had been awarded a contract for 1,000,000 shells. The formal contract was received June 3, 1941. It was agreed that a certain amount of these shells would be made according to the British specifications, but that others were to be made according to Navy specifications which called for a change in the thread in the nose -- into which a detonating fuze was screwed at the loading plants -- from the British thread to the U. S. Standard .625" - 3NS2. This contract bore the Navy designation "NOrd. 136" and was assigned the Company's GO 472000. Shipment of the entire 1,000,000 shells -- all produced at the Company's plant -- was made between October 30, 1941, and June 4, 1942.

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HISTORY OF THE CONTRACTS - (Con't.)

Third Order. (NOrd. 210 -- US&S GO 479100). On July 7, 1941, the Navy made a formal inquiry regarding additional production of the 20 MM. H. E. Shell. On July 14, the Company said it would be willing to undertake production of an additional 1,000,000. Advised that this would be acceptable the formal bid and quotation was made on August 28, and on September 26 the Company was notified that it had been awarded a contract for this amount. The formal contract was received on October 11. Delivery of the entire order was called for between January 1, and June 30, 1942. The entire order was shipped between January 10, and May 27, 1942, the order being filled a little more than a month ahead of schedule.

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Fourth Order. (NOrd. 299 -- US&S GO 486800). Four days after the first shipment under the Third Order had gone forward, the Navy again inquired regarding production of an additional 9,000,000 shells. By this time the Company had reached peak production since all machinery had been acquired and installed. A quotation was made January 26, the order being received March 16, 1942. Deliveries -- which were to be at the rate of 1,000,000 a month -- were to commence July 1, 1942, and to conclude in April, 1943. The first shipment was made on June 23. Due to difficulties with the steel, however, production was slowed to some extent, the final shipment not being made until May 20, 1943.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS - (Con't.)

Fifth Order. (NOrd. 3263 -- US&S GO 503330). The Westinghouse Air Brake Company, which had received orders from the United States Navy for production of 20 MM. Anti-Aircraft Projectiles, Mark III, simultaneously with the orders awarded the Company, negotiated with the Navy for the production of 14,400,000 shells on March 15, 1943. However when WABCO received a letter of intent from the Navy for this number, an influx of other war orders for other items had been received and it was felt that the shells should all be produced by one facility. With the consent of the Navy, therefore, the order -- received formally on May 5, 1943 -- was sub-contracted to The Union Switch & Signal Company.

The first shipment went forward June 1, 1943, with future shipments to be made in the amount of 1,200,000 shells a month. However it was during the life of this order that new, and radically different, inspection requirements were set up by the Navy for the shell. These requirements included individual inspection of each shell for seams. Some difficulty in procurement of the steel from which the shell was machined also was experienced. The inspection difficulties were ironed out after vigorous complaint had been lodged with the Navy Department by the Company, and supplies of steel again began to flow. The final shipment, however, was not made until June 21, 1944.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS - (Con't.)

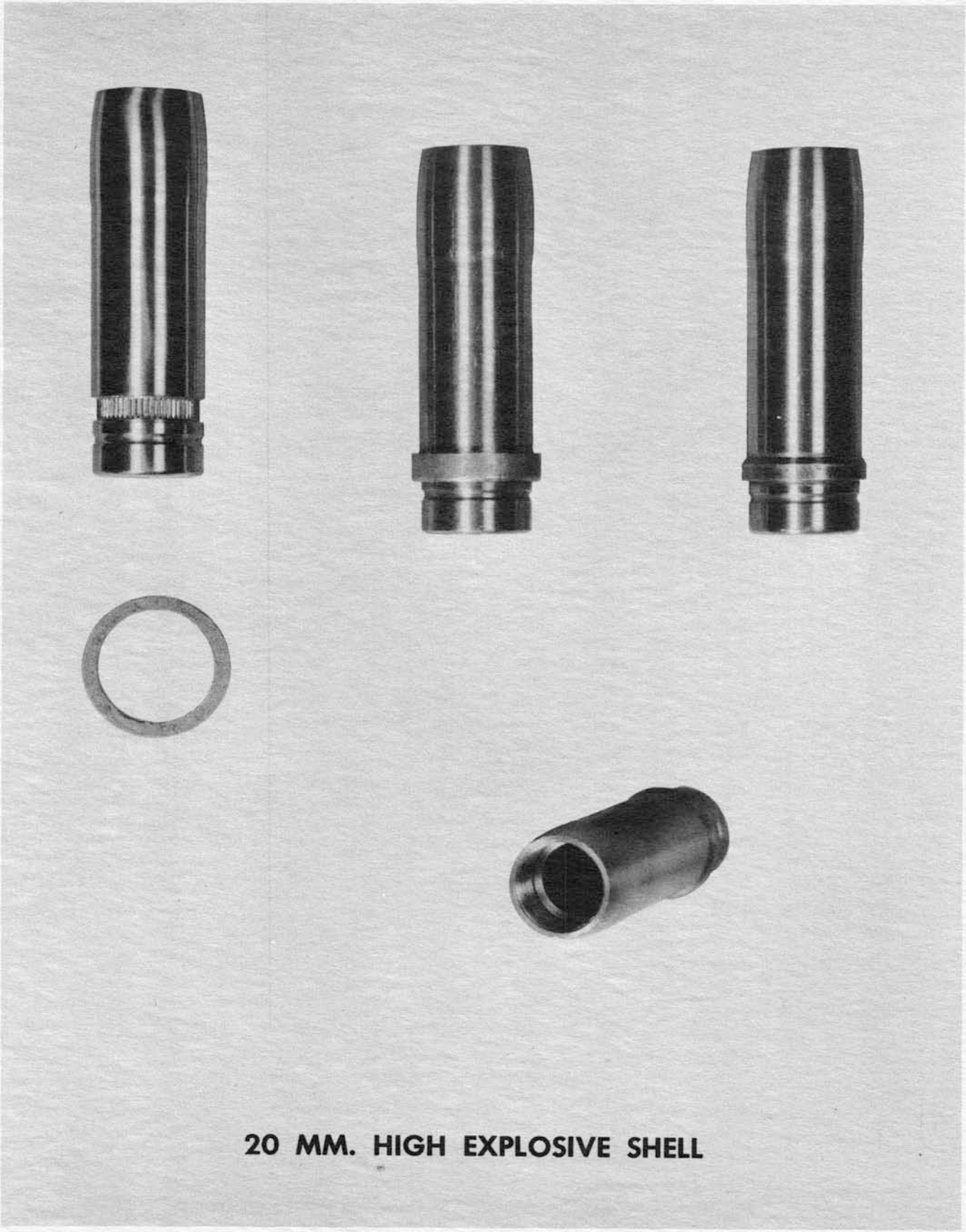
Sixth Order. (NOrd. 4933 -- US&S GO 512150). This order, also for a total of 14,400,000 shells, was awarded directly to the Company by the Navy on December 4, 1943. Shipments -- at the rate of 1,200,000 a month -- were to start at the conclusion of shipments on the previous order, NOrd. 3263. The first shipment, in the amount of 300,000 shells, was made by the Company on July 20, 1944. The inquiries on this order were made November 6, and quotations forwarded November 18, 1943.

On May 27, 1944 -- even before the first shipment was made -- the order was increased to a total of 14,402,880 shells, the extra pieces being for test projectiles.

Shipments during August, September and October, 1944, were in the amount of 1,100,000 shells each month. In November a total of 900,000 went forward, followed by the same number in December.

In January, 1945, the Company shipped a total of 1,600,000 shells, and it was on January 24 that the Company was notified that the order would be cut back to a total of 8,700,000 pieces in all. Inquiry disclosed -- on February 5, 1945 -- that the reason for the cut-back was that the Navy had more Mark III shells than it required. Permission was sought by the Company to revise shipping schedules so as to taper off on production. On February 14, the Navy advised that the cut-back

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY



20 MM. HIGH EXPLOSIVE SHELL

HISTORY OF THE CONTRACTS - (Con't.)

would be amended, so that the Navy would accept up to 9,500,000 shells, with the final shipments to be made not later than April 15, 1945.

Shipments during February were in the amount of 1,200,000 shells, followed by 1,000,000 in March, while the final 300,000 pieces -- closing out the order at 9,500,000 shells -- went forward on April 13, 1945.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS AND DIFFICULTIES:

With the exception of the loading, capping with a nose fuze, and insertion into the shell case, the 20 MM. shell was produced complete by the Company. Starting with bars of 27/32" cold drawn steel, stock -- (originally 13/16" stock under British orders) -- the shell was machined, ground, fitted with a rotating band, stenciled and packed for shipment, all in the one department.

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A battery of some 14 multi-station automatic screw machines performed a series of operations on the bar stock, during which it was turned, shaved, grooved, undercut, knurled, drilled, counterbored, reamed, tapped and cut off to length, a total of .006" being left on the piece for grinding.

MANUFACTURING OPERATIONS, ETC. - (Con't.)

The piece then was centerless ground. Four machines were devoted to this work. Then followed assembly of the rotating band to the shell on a swaging machine. Following this the band was machined, the base end faced and radiused, after which the nose was re-tapped. This final operation later was discontinued, having been used only on the first production of the shell.

There were intermittent steps for cleaning, process inspection and gaging before the shell went to a group of Company inspectors. Here some 17 different inspections, from visual to gage, were made.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

After clearing the inspectors the shell was stenciled on a special machine which threw it into a trough leading to a greasing pan. Then a traveling belt carried it to a draining pan after which the shell was packed in special cartons.

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Under the British contract -- and for some time after the Navy took the contracts over -- the rotating bands were made of copper. Then gilding metal -- (a composition of copper, iron, lead and zinc in certain specified proportions) -- was called for and was used up to the end of production.

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MANUFACTURING OPERATIONS, ETC. - (Con't.)

The department in which the 20 MM. Shell was produced was so laid out that there was a continuous flow in production -- from the stock-room to the automatics, to cleaners then to grinders, to the other operations down to the Company inspectors, weighers, etc., thence to Navy inspectors and then to stenciling, greasing and packing. There was no back-tracking anywhere along the line.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The Company's inspection department also was re-arranged so that production was stepped up. Originally the shell passed through a series of inspections before banding. After banding and subsequent operations the shells were returned to another section of the inspection department for visual and gage inspection, then forwarded to the Navy inspectors.

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Under the new set-up, a "T"-shaped table was placed at one end of the department. The completed -- but unstenciled -- shells were taken to a group of inspectors at the cross-bar of the "T". Each shell was given a complete visual inspection, both internally and externally, replaced in a tray and a number of them were

MANUFACTURING OPERATIONS, ETC. - (Con't.)

moved in a trough-like conveyor rack around the bar of the "T" to other inspectors located on each side of the shank of the "T". The conveyor rack was located just above eye-level so that the moving trays did not distract the attention of the inspectors, or lead to eye-fatigue.

Tests for eccentricity, crimp, diameter of the rotating band, base, body and bourrelet, bore and counterbore, and for other dimensions were made before the shells are weighed. The inspectors on either side of the "T"'s shank performed similar operations so that there was no confusion of effort, and the work passed along in an unending stream.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Another practice -- installed just before peak production was attained -- was the location of "scrap" boxes at each machine. These were of two types. One -- painted green -- was for shells about which the machine operator was doubtful. The other was for shells that definitely were to be scrapped because of damage. The "doubtful" shells were taken to the Salvage Department and checked. If usable the shells were returned for the next sequence in operations until they finally arrived for final inspection.

MANUFACTURING OPERATIONS, ETC. - (Con't.)

Some 500 shells a day were added to the department's output by the use of the two types of "scrap" boxes. Of the shells placed in the "green" box, fully 85% were found to be usable. Prior to this practice all "doubtful" and scrap shells were placed in the same box, later all having to be sorted and inspected.

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A device developed by the Company, made use of a small turret lathe on which a shell with a damaged rotating band was placed. The band was quickly removed with a special cutting tool, and the shell was returned for re-banding.

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Not only was there a considerable saving in time and operations through the use of the two "scrap" boxes, and of the band-removing tool, but the scrap percentage was lowered. It had run as high as 15% during the early life of the contracts, but towards the end of 1944, it had been cut down to approximately 4.5%, having previously been reduced to a little more than 5%.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS, ETC. - (Con't.)

One continuing problem in the manufacture of this shell was the grade of steel supplied. When the British contract was in force the steel specified -- while readily machineable -- was subject to surface cracks because of its high sulphur content. This caused considerable trouble and often led to rejection of items that further tests proved to be acceptable.

When the Navy assumed the contract -- and subsequently -- the specifications called for a steel which was harder to machine and which differed radically from that used by the British. In addition, the manufacturing processes, and the composition of the steel were constantly being changed by the Navy, the steel mills also changing the composition. The result was that batches of steels of different heats were received. Some were very soft, others quite hard. These changes were being made in an effort to obtain a finer grain structure with no change in the physical characteristics of the steel. However, some of the changes, while improving the structure, produced steel which could only be machined at a high maintenance cost for critical tools, and thus with a consequent decrease in production.

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Steel procurement was a major and persistent difficulty from the start of the Navy contracts. The Company's Purchasing Department attacked the problem with vigor and -- upon several occasions -- even

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS, ETC. - (Concluded)

secured bar stock from mills in Ohio, and from Buffalo, N. Y. On one or two occasions stock was "borrowed." As a result there was only one 24-hour period throughout the Company's shell-manufacturing experience when the Department was forced to close down because of the lack of material.

* * *

In machining the 20 MM. Shell, the Company had to produce an item that had the finest grade of machine finish on the outside, while nearly all other surfaces had to have a machine finish of good quality.

The interior had to be kept free from sharp edges, fins and burrs. Concentricity of cylindrical surfaces had to be maintained -- the tolerance on concentricity not being allowed to exceed .004".

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

BREECH BLOCK PARTS FOR U. S. ARMY HOWITZERS

(United Engineering & Foundry Co., Contracts)

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As Sub-Contractor, The Union Switch & Signal Company Shipped 324,125 Parts in Fifty Months, and in Turn Sub-Contracted Production of An Additional 132,899 Pieces -- Lack of Materials Delayed Production of Some Items -- No Reports of Firing Test Failures of Any of the Parts -- All Pieces Passed Every Interchangeability Test

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In the period of fifty months between May 7, 1941, and July 3, 1945, the total of 324,125 fully machined parts used in the breech blocks of U. S. Army Howitzers of the 105 MM. and other sizes, was shipped by The Union Switch & Signal Company, producing as a sub-contractor to the United Engineering & Foundry Company, Pittsburgh, Pa. In addition, the total of 132,899 other parts -- production of which had been sub-contracted by the Company to the Westinghouse Air Brake Company also were produced and shipped. Some thirty-seven orders were received by the Company for this production, with two additional orders for howitzer parts received from Cowdrey Machine Division, American Type Founders, Inc., Fitchburg, Mass. The production of the pieces on these two orders also was sub-contracted to the Westinghouse Air Brake Company.

A total of twenty-nine different parts was called for in the orders, twenty of the parts being produced in entirety by the Company, the production of the other nine parts being sub-contracted. In nearly every instance the Company and its sub-contractor met production and shipment schedules, but there were some delays, at times, due to lack of materials, or of forgings from which certain of the parts were machined.

Most of the orders received by the Company were completed in full. Some were partially cancelled, others cancelled complete before any production had been started on the items called for. Also

included in some of the orders were some items of partially machined pieces, or for certain excess material.

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The Company was among the first in this country to produce the parts, having been approached by the prime contractor in September, 1940, with request to submit quotations on a long list of items.

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Government inspectors, stationed at the Company's plant, as well as the prime contractor, praised the output on the contracts, both for its uniformity and general excellence. Parts furnished by the Company -- either of its own production, or under its own sub-contracts -- when submitted to Government tests, passed them without exception. Among these tests were the "interchangeability of parts" tests. In this the various pieces were assembled, then dis-assembled and "scrambled", then re-assembled. It also is a matter of record that the Company never received a report of failure of any part furnished by it, in any of the firing tests.

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During peak production the Company had about 100 men and women -- working in five departments -- to produce the items. These employes worked a triple-turn, seven-day week.

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Existing machinery within the Company's plant was used to produce the twenty parts made there. The Company also produced and supplied its own special tools, jigs, fixtures and gages, and developed techniques of manufacture that not only resulted in greater production, but also a finer finished piece in many instances. Some changes -- which received the approval of Government authorities -- also were made in the detailed instructions that were furnished for various of the items. Some of the methods employed in previous production of the parts by Army Arsenal operators, were found to be slow. The changes worked out by the Company enabled savings to be made in time in certain milling, lathe and grinding operations.

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Materials used in making the parts included various grades and kinds of steel, in strip, rod and bar stock; nickel silver; manganese bronze, aluminum, and steel forgings. Two of the items produced by the Company were made from forgings. These were the Trigger Fork and the Trigger Shaft. Four of the items sub-contracted by the Company to the Westinghouse Air Brake Company, also were machined from forgings. The items were the Extractor, Sear, Lever and the (large) Handle. Inability to secure these forgings from time to time, delayed production of the items. Difficulty in securing sufficient amounts of material for some of the other items also was experienced, and it was necessary to enlist the aid not only of the prime contractor but of the Government to secure the necessary stock.

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The following table shows the Part number and name, and quantity of each produced and shipped by the Company:-

Number of Part	Name of Part	Number of Pieces Shipped by Company
A- 8128	Countersink Screw.	13,370
A- 8365	Plug Screw - (large)	12,377
A- 8380	Key.	15,820
A- 8384	Sleeve	14,256
A- 8388	Pivot - (slotted).	10,462
A- 8389	Pivot Pin.	15,789
A- 8391	Pin Screw.	18,394
A- 8440	Detent	16,678
A- 8865	Crosshead.	11,454
A- 8867	Lock Screw - (small)	11,616
A-12121	Leveling Plate	18,365
A-12130	Plug Screw - (small)	12,236
A-12579	Firing Pin Bushing	16,750
A-12755	Firing Pin	28,964
A-21090	Lock Screw - (large)	12,042
A-21091	Pivot - (keyed).	11,135
A-21299	Bushing.	16,450
A-12132	Trigger Fork.	17,577
A-25602	Retarding Screw.	38,260
C- 8669	Trigger Shaft.	12,130
	T O T A L	324,125

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Also shipped by the Company on orders from the prime contractor were 100 feet of 11/16" steel rod; 600 feet of cold rolled steel bar stock; 826 partly machined Trigger Shaft forgings, and 343 partly machined Trigger Fork forgings.

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On the orders for parts, the production of which was sub-contracted by the Company to the Westinghouse Air Brake Company, the following table shows the Part number and name, and quantity of each shipped:-

Number of Part	Name of Part	Number of Pieces Shipped by WABCO
A- 8127	Catch.	12,659
A- 8362	Handle - (small)	10,580
A- 12133	Firing Pin Holder Sleeve . . .	12,971
B- 8031	Sear	15,237
B- 8187	Firing Pin Holder.	25,993
B- 8194	Handle - (large)	13,193
B-163342	Bearing Strip - (angle edge) .	15,815
B-164143	Bearing Strip - (straight edge) .	766
C- 8668	Extractor.	15,318
C- 8670	Lever.	10,367
	T O T A L	132,899

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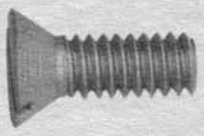
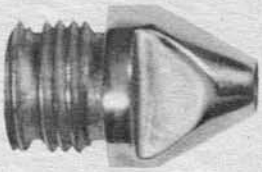
PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

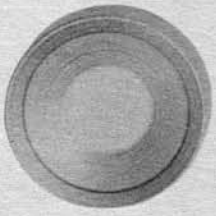


COUNTERSINK SCREW
A-8128



FIRING PIN BUSHING
A-12579

PLUG SCREW
A-12130



LEVELING PLATE
A-12121

PLUG SCREW
A-8365

105 MM. HOWITZER PARTS (PLATE I)

Included in the foregoing table, under the total of 25,993 Firing Pin Holders, are 6,600 pieces which Westinghouse Air Brake Company made under a special order from the Pittsburgh Ordnance District, sub-contracted to it by the Company. Also, included in the total of 15,318 Extractors, are 1,639 of these pieces which were made for the Cowdrey Machine Division, American Type Founders, Inc., under sub-contracts from the Company.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The Westinghouse Air Brake Company also was asked to ship to the prime contractor -- the United Engineering & Foundry Company -- a total of 625 rough forgings from which the Extractors were machined, and also 370 of the heat-treated forgings from which the large Handles were made. The orders were closed out in the amounts of 386, and 263 pieces respectively.

* * *

HISTORY OF THE CONTRACTS:

(NOTE: In nearly every order received by the Company, there were from one to nine pieces, the production of which was sub-contracted by the Company. In the resumes following, these items are listed separately.)

HISTORY OF THE CONTRACTS - (Con't.)

First Order - (GO 416600) - 37,340 pieces

On September 25, 1940, the Company received an inquiry from the United Engineering & Foundry Company, Pittsburgh, Pa., regarding production of a number of parts used in the assembly of breech blocks for 105 MM. and other size Howitzers used by the United States Army. The quotation was forwarded October 14. One month later to the day -- November 14, 1940 -- an order was received for twenty-nine different parts to be furnished in varying amounts. Six of the parts were to be made from forgings to be furnished by the prime contractor. In accepting the order the Company, in turn, sub-contracted production of nine of the parts to the Westinghouse Air Brake Company -- (hereafter identified as WABCO). The accompanying table shows the items and quantities of each called for:-

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Part	Quantity	Part	Quantity
Leveling Plate	2,380	Detent	1,489
Lock Screw - (large)	1,489	Bushing	1,608
Crosshead	1,489	Key	1,370
Pivot - (slotted)	1,489	Sleeve	1,489
Pivot - (keyed)	1,489	Pivot Pin	1,489
Trigger Shaft	1,489	Pin Screw	1,489
Retarding Screw	4,765	Lock Screw - (small)	1,489
Firing Pin Bushing	2,380	Countersink Screw	1,489
Trigger Fork	1,787	Plug Screw - (small)	1,608
Firing Pin	3,574	Plug Screw - (large)	1,489

Sub-contracted to WABCO - 14,672 pieces

Catch	1,370	Extractor	1,475
Handle - (small)	1,190	Handle - (large)	1,180
Bearing Strip	2,360	Lever	1,180
Firing Pin Holder	1,770	Sear	2,360

Firing Pin Holder Sleeve 1,787

HISTORY - First Order - (Con't.)

Of the twenty parts produced by the Company, the first pieces went forward on May 7, 1941, the order being completed with a final shipment of 124 Trigger Forks on December 15, 1941.

Deliveries of the nine parts sub-contracted to WABCO were made between February 26, and September 18, 1941. Some delay in the shipments resulted from the fact that the prime contractor was not able to furnish forgings for four of the parts, promptly.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Second Order - (GO 472200) - 23,881 pieces

In response to a telephoned inquiry on May 12, 1941, quotations were made by the Company for additional production. The order, received on May 29, called for:-

2,047 Firing Pins; 2,728 pieces each of the Trigger Forks, Bushings and Detents, and 1,365 pieces each of the Countersink screws, Crossheads, Keys, Pivot Pins, Pivots - (slotted), Pin Screws, Sleeves, Pivots - (keyed), Firing Pin Bushings and Trigger Shafts.

Sub-contracted to WABCO - (8,460 pieces) was the production of 682 Sears; 1,638 Catches; 2,047 Handles - (large); 1,365 Extractors, and 2,728 Firing Pin Holders.

HISTORY - Second Order - (Con't.)

The Company shipped the bulk of the items it produced during the period between October 18, 1941, and July 31, 1942. There were a few last pieces which were not shipped until February 2, 1943, however, when the order finally was marked "Completed."

Shipment of the five items sub-contracted to WABCO was completed by March 20, 1942.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Third Order - (GO 473000) - 15,475 pieces

The full twenty-nine parts were called for in this order, received on June 11, 1941. The inquiry had been made on May 5, with quotations going forward on May 7. The parts, and quantity of each:-

Firing Pins, 1,790; Keys, 550; Leveling Plates, 960; Bushings and Plug Screws - (large), 695 each; Lock Screws - (large), Lock Screws - (small), and Countersink Screws, 605 each; Pin Screws, Firing Pin Bushings and Trigger Forks, 1,190 each. Also 600 pieces each of Detents, Crossheads, Pivot Pins, Pivots - (slotted), Plug Screws - (small), Retarding Screws, Sleeves, Trigger Shafts and Pivots - (keyed).

Sub-contracted to WABCO - (6,525 pieces) were 550 Catches; 600 Extractors; 715 Firing Pin Holder Sleeves; 955 Bearing Strips; 1,190 Firing Pin Holders; 1,075 Sears; and 480 pieces each of Levers and Handles, both (large), and (small).

HISTORY - Third Order - (Con't.)

Delivery of all the parts produced by the Company was made between October 18, 1941, and July 31, 1942, while the items produced by WABCO were forwarded between October 29, 1941, and June 22, 1942.

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Fourth Order - (GO 475625) - 13,000 pieces

Another order for all twenty-nine parts was received by the Company on October 21, 1941. It called for:-

Trigger Shafts, Pivots - (keyed), Retarding Screws and Detents, 480 pieces each; Countersink Screws, Pivot Pins, Sleeves, Plug Screws - (small), and Pivots - (slotted), 485 pieces each; Lock Screws, both the large and small, 490 pieces each; Keys, 445; Plug Screws - (large), and Bushings, 535 pieces each; Crossheads, 495; Leveling Plates, 780; Firing Pin Bushings, 955; Trigger Forks, 960; Firing Pins, 1,430 and 1,540 Pin Screws.

Sub-contracted to WABCO - (5,265 pieces) were 445 Catches; 770 Bearing Strips; 390 Levers; 865 Sears; 575 Firing Pin Holder Sleeves; 385 Handles - (small); 390 Handles - (large); 485 Extractors and 960 Firing Pin Holders.

The Company delivered its production between December 17, 1941 and January 7, 1943, while WABCO made deliveries between October 29, 1941, and June 22, 1942.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

FIRING PIN
A-12755

PIN SCREW
A-8391

PIVOT PIN
A-8389

DETENT
A-8440

KEY
A-8380

105 MM. HOWITZER PARTS (PLATE II)

HISTORY OF CONTRACTS - (Con't.)

Fifth Order - (GO 485500) - 10,214 pieces

The prime contractor -- on December 17, 1941 -- made inquiry regarding additional production, a quotation being forwarded the same day. The order was received February 24, 1942, and called for:-

Countersink Screws, Crossheads, Keys, Pivot Pins, Pivots -- both "slotted" and "keyed" --, Sleeves, Pin Screws and Trigger Shafts in the amount of 786 pieces each, and also 1,570 pieces each of the Detents and Bushings.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Sub-contracted to WABCO - (4,090 pieces), was that part of the order calling for 944 Catches, 1,180 Levers, 786 Extractors, and 1,180 Handles - (large).

Delivery of its parts was made by the Company between March 7, 1942, and January 30, 1943. WABCO deliveries were made during the same period.

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Sixth Order - (GO 486500) - 33,875 pieces

This was received on February 25, 1942, as a follow-up of the Fifth Order. It was based on quotations made by the Company on January 7, 1942, following an inquiry made on January 5. Substantial

HISTORY - Sixth Order - (Con't.)

quantities of each of the parts previously produced were called for. Deliveries were to be concluded before the end of the year. This order, with its demand for speedy shipment, reflected the entrance of the United States into the war, and the increased need for items of ordnance. The following tables gives the parts and quantities of each item ordered:-

Part	Quantity	Part	Quantity
Leveling Plate	1,700	Lock Screw - (small)	1,035
Lock Screw - (large)	1,035	Pivot Pin	1,415
Crosshead	1,415	Pin Screw	1,415
Pivot - (slotted)	1,415	Countersink Screw	1,420
Pivot - (keyed)	1,030	Plug Screw - (small)	2,440
Trigger Shaft	1,405	Plug Screw - (large)	1,035
Retarding Screw	3,950	Firing Pin	3,010
Detent	1,795	Trigger Fork	1,675
Bushing	1,875	Firing Pin Bushing	2,060
Key	1,335	Sleeve	1,415

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Sub-contracted to WABCO - (13,120 pieces). The nine parts being produced for the Company under sub-contracts, were called for in the following amounts:-

Catch	1,415	Sear	1,360
Bearing Strip	1,825	Lever	1,405
Handle - (small)	915	Handle - (large)	1,405
Firing Pin Holder	1,600	Extractor	1,405
Firing Pin Holder Sleeve	1,290		

The Company made deliveries of all parts it produced within the schedule set up. WABCO, however, while it made first deliveries of some parts on March 19, 1942, did not make final shipments of all

HISTORY - Sixth Order - (Con't.)

items until April 22, 1943 -- nearly five months behind schedule. This was due to the inability of the company producing the forgings for the prime contractor to secure the necessary steel. The aid of the Cleveland Ordnance Department finally was enlisted by the United Engineering & Foundry Company, and a directive was issued by means of which the steel finally was obtained.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Seventh Order - (GO 487970) - Sub-contracted to WABCO - 344 pieces.

This order was received on April 1, 1942. It called for 344 Firing Pin Holder Sleeves. The parts were shipped complete by July 1, 1942.

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Eighth Order - (GO 488125) - 7,135 pieces

Dated April 4, 1942, this order called for fifteen parts to be produced by the Company and for the nine parts, the production of which had been sub-contracted to WABCO. Shipments were completed by the Company, and also by WABCO, on schedule. The items ordered, and the quantity of each, follow:-

450 Leveling Plates; 280 pieces each of the large and the small Lock Screws and large Plug Screws; 380 Countersink Screws; 275 Pivots - (keyed); 1,050 Retarding Screws; 375 Crossheads; 355 Keys; 480 De-

HISTORY - Eighth Order - (Con't.)

tents; 500 Bushings; 800 Firing Pins; 600 Plug Screws - (small); 495 Trigger Forks and 475 Trigger Shafts.

Sub-contracted to WABCO - (3,495 pieces). Called for in this order were 375 pieces each of the Catch, Extractor, Handle - (large), and Lever; 245 small Handles; 485 Bearing Strips; 495 Sears; 425 Firing Pin Holders and 345 Firing Pin Holder Sleeves.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Ninth Order - (GO 490100) - 52,845 pieces

Calling for greater quantities of each of the twenty-nine parts than hitherto had been ordered, this order was received by the Company on June 10, 1942. Delivery of the parts was to be completed on or before December 15, 1942. However this schedule was adhered to, mainly because of the inability to secure material and forgings. Some items produced by the Company were shipped complete by August 14, 1942, but the final shipment of other items was not made until April 12, 1944.

In the tables which follow on the next page are given the items and the amount of each ordered; together with the items which were sub-contracted to WABCO for production, together with the quantity ordered of each part.

HISTORY - Ninth Order - (Con't.)

Part	Quantity	Part	Quantity
Leveling Plate	2,590	Sleeve	2,200
Lock Screw - (large)	1,600	Firing Pin Bushing	3,230
Lock Screw - (small)	1,305	Plug Screw - (small)	3,850
Countersink Screw	2,210	Firing Pin	4,750
Retarding Screw	6,410	Bushing	2,940
Crosshead	2,210	Detent	2,810
Key	2,090	Plug Screw - (large)	1,600
Pivot Pin	2,210	Pivot - (keyed)	1,600
Pivot - (slotted)	2,200	Trigger Fork	2,630
Pin Screw	2,210	Trigger Shaft	2,200

Sub-contracted to WABCO - (20,565 pieces).

Catch	2,210	Extractor	2,190
Bearing Strip	2,320	Handle - (large)	2,190
Handle - (small)	1,410	Lever	2,185
Firing Pin Holder	2,620	Sear	2,920
Firing Pin Holder Sleeve	2,020		

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Tenth Order - (GO 490650) - 2,946 pieces

Received June 18, 1942, this order called for 982 pieces each of the Firing Pin, Trigger Fork and Bushing. Shipment complete was called for on, or before, November 1, 1942. The Company made its first shipment October 24, 1942, the last on April 22, 1943.

Sub-contracted to WABCO - (2,946 pieces). The Sear, Firing Pin Holder and Firing Pin Holder Sleeve were called for, each also in the amount of 982 pieces. Inability to secure forgings held up shipments, the first pieces not going forward until January 21, the last on April 19, 1943.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF CONTRACTS - (Con't.)

Eleventh Order - (GO 494175) - 47,515 pieces

This was another large order, inquiries on which were received on August 20, 1942. Quotations were forwarded August 24, the order being received on September 12. Shipment of parts was to start April 1, 1943, with delivery of not less than 400 parts monthly. The first was made well ahead of schedule -- going forward October 26, 1942 -- while final shipments were made by the Company on May 2, 1944. Of the nine parts, the production of which was sub-contracted to WABCO, the first deliveries were made in March, 1943, with final shipments on January 31, 1944. The table gives the parts and quantities ordered:-

Part	Quantity	Part	Quantity
Leveling Plate	4,840	Sleeve	1,280
Lock Screw - (large)	2,275	Firing Pin Bushing	380
Lock Screw - (small)	2,405	Firing Pin	4,235
Countersink Screw	1,500	Bushing	745
Retarding Screw	9,600	Detent	2,020
Crosshead	1,770	Plug Screw - (large)	2,380
Key	1,890	Pivot - (keyed)	2,380
Pivot Pin	1,780	Trigger Fork	2,565
Pivot - (slotted)	1,780	Trigger Shaft	1,920
	Pin Screw	1,770	

Sub-contracted to WABCO - (23,315 pieces).

Catch	1,640	Sear	940
Bearing Strip	4,985	Lever	1,785
Handle - (small)	2,295	Extractor	2,500
Firing Pin Holder	4,335	Handle - (large)	1,785
	Firing Pin Holder Sleeve	2,550	

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF CONTRACTS - (Con't.)

Twelfth Order - (GO 499675) - 36,021 pieces

On February 12, 1943, the Company was in receipt of still another order for Howitzer Parts, the order being based on quotations made by the Company on January 21. The original amounts called for in the order, were increased -- in varying degrees -- on March 9. Deliveries were scheduled to start May 1, but the Company made first delivery of some of the parts on March 31, the final shipments being made on June 3, 1944. Of the nine parts sub-contracted to WABCO, first deliveries were made on July 6, 1943, the final shipments going forward on April 17, 1944. The order -- as amended on March 9, 1943 -- called for:-

Beveling Plates, 2,795; Lock Screws - (large), 1,515; Lock Screws - (small), 1,028; Countersink screws, 1,395; Retarding Screws, 5,910; Crossheads, 495; Keys, 962; Pivot Pins, 1,390; Pin Screws, 1,028; Detents, 1,820; Sleeves, 1,495; Firing Pin Bushings, 5,030; Firing Pins, 5,425; Bushing, 1,372; Plug Screws - (large), 1,495; Pivots - (keyed), 130; Pivots - (slotted), 342; Plug Screws - (small), 1,220; Trigger Forks, 1,160, and Trigger Shafts, 14.

Sub-contracted to WABCO - (15,622 pieces). A total of 1,445 Catches; 1,615 Bearing Strips; 1,390 Handles - (small); 2,211 Firing Pin Holders; 3,058 Sears; 594 Levers; 1,727 Extractors; 1,495 Handles - (large), and 2,087 Firing Pin Holder Sleeves, was called for on this order.

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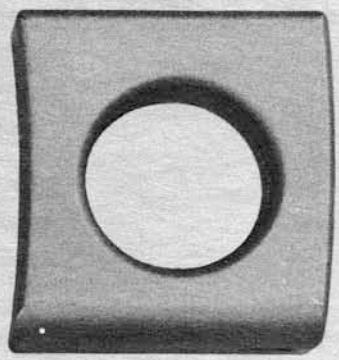
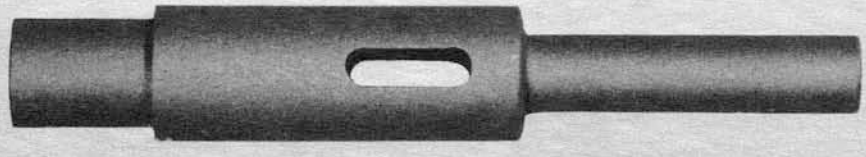
PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

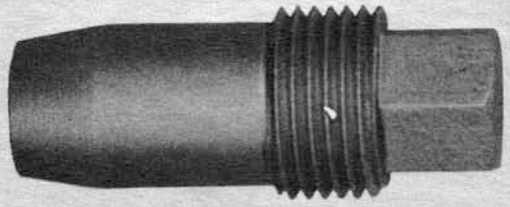


CROSSHEAD
A-8865

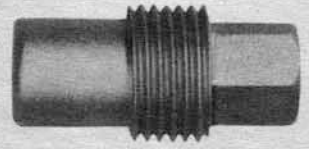
RETARDING SCREW
A-25602



PIVOT (SLOTTED)
A-8388



LOCK SCREW A-21090



LOCK SCREW A-8867

105 MM. HOWITZER PARTS (PLATE III)

HISTORY OF CONTRACTS - (Con't.)

Thirteenth Order - (GO 500070) - 660 pieces

Originally this order -- received on February 25, based on quotations made February 5, 1943 -- called for 500 pieces each of Detents, Firing Pins and Firing Pin Bushings, together with an additional 500 pieces each of the Firing Pin Holders and Extractors. The latter two items were being produced by WABCO on sub-contracts from the Company.

On April 1, however, the prime contractor cancelled the order with but two exceptions. The order for the Firing Pin Bushings was to be closed out at 160 pieces, while the 500 Detents were to be shipped in full. The Detents were forwarded October 9, 1943, but the Firing Pin Bushings were not shipped until in January and February, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

- - -

Fourteenth Order - (GO 501885) -- 550 pieces

This order -- received April 8, 1943 -- called for 550 Trigger Shafts. Quotations had been made on April 1. The order was filled complete, the parts being shipped between April 23, and May 15, 1943.

- - -

HISTORY OF CONTRACTS - (Con't.)

Fifteenth Order - (GO 503525) - 7,023 pieces

All twenty parts were called for on this order, together with the nine parts being produced by WABCO, but a cancellation of a number of the items was received about two months after the order had been placed. The order was received May 14, 1943, the schedule calling for shipments to begin at the conclusion of the Twelfth Order - (GO 499675). The cancellation notice was received July 7, 1943. The items produced by the Company, and the amounts, follow:-

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

540 Leveling Plates; 469 Lock Screws - (large); 545 Countersink Screws; 2,560 Retarding Screws; 273 Sleeves; 526 Firing Pins; 150 Detents; 600 Plug Screws - (large); 1,360 Plug Screws - (small).

Sub-contracted to WABCO - (1,450 pieces). On this order WABCO produced and shipped:- 462 Catches; 650 Handles - (small); 338 Handles - (large).

- - -

Both the Sixteenth Order - (GO 503530), and the Seventeenth Order - (GO 503535) were also received on May 14, 1943, and both were cancelled complete on February 19, 1944. Firing Pins, Firing Pin Bushings, Firing Pin Holder Sleeves, Firing Pin Holders, Trigger Forks and Sears were ordered in various amounts.

- - -

HISTORY OF CONTRACTS - (Con't.)

Eighteenth Order - (GO 507380) - 1,291 pieces

On August 23, 1943, the Company received another order for Howitzer Parts. The order later was cancelled except that shipments were taken on four items. A total of 1,050 Retarding Screws was shipped on December 31, 1943, while 130 Detents had been shipped on October 9. An order for 135 Plug Screws - (large), was closed out at 98 pieces on January 31, 1944, while an order for 140 Plug Screws - (small), was closed out at 13 pieces on February 25, 1944.

- - -

Nineteenth Order - (GO 507840) - 1,921 pieces

This order -- also received on August 23, 1943 - likewise was cancelled in part on February 19, 1944. A total of 1,885 Retarding Screws was shipped, while an order for 280 Detents was closed out at 36 pieces.

Sub-contracted to WABCO - (419 pieces). Included in this order were a number of parts which were to be produced by WABCO. Of an order for 245 Catches, 73 pieces were shipped. Of an order for 285 Handles - (small), 275 pieces were shipped, while of an order for 245 Handles - (large), only 71 pieces were shipped.

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF CONTRACTS - (Con't.)

Twentieth Order - (GO 519270) -- sub-contracted in entirety to WABCO.

Received April 4, 1944, this order called for 788 Bearing Strips -- (Part # B-164143 - straight edge)-- to be shipped as "soon as possible." The order was sub-contracted to WABCO which reported only enough material on hand to complete 766 pieces. The prime contractor agreed to close out the order at this figure, and the parts were shipped between June 15 and 20, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

- - -

Twenty-first Order - (GO 519390) - 900 pieces

This called for 900 Bushings, and was dated April 10, 1944. The items were to be shipped "in two or three weeks." Shipments began on April 17, and concluded June 22, 1944.

- - -

Twenty-second Order - (GO 520430)

The prime contractor sent an order to the Company on April 25, 1944, calling for shipment of 100 feet of 11/16" steel bar stock -- the material from which the Pivot - (slotted) was machined. The material was shipped on May 5, 1944.

- - -

HISTORY OF CONTRACTS - (Con't.)

Twenty-third Order - (GO 520510) - 16 pieces

A total of 16 completely machined, and 182 partly machined, Trigger Shafts was called for in this order, received April 26, 1944. The prime contractor cancelled the latter part of the order on May 6. The 16 completely machined parts went forward on May 16, 1944.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Twenty-fourth Order - (GO 521500) - 79 machined, 343 partly machined, Trigger Forks

Received on May 16, 1944, this order called for 79 completely machined Trigger Forks, and 631 partly machined pieces of the same part. Work on the latter had been held up when the Fifteenth Order - (GO 503525), was cancelled in part. Delivery was requested in three weeks. Investigation disclosed that the 79 completely machined parts could be shipped, but that only 343 partially machined pieces were on hand. The prime contractor agreed to close out at this figure and the entire 422 pieces were shipped on June 22, 1944.

- - -

HISTORY OF CONTRACTS - (Con't.)

Twenty-fifth Order - (GO 524463) - sub-contracted in entirety to WABCO.

Calling for 10 Levers and 43 Extractors, this order was sub-contracted in its entirety to WABCO. The order was received July 11, 1944, and all pieces were shipped out on July 21, 1944.

- - -

Twenty-sixth Order - (GO 525185) - Partly machined forgings

Another "clean-up" order -- received by the Company on July 24, 1944 -- this called for 911 partly machined Trigger Shaft forgings. On August 5, the Company advised that only 828 such pieces were on hand. The prime contractor agreed to close out at this figure. The parts were shipped August 25, 1944.

- - -

Twenty-seventh Order - (GO 525470) - 395 pieces

A total of 395 Firing Pins was called for in this order received July 31, 1944. The items were to be "shipped as soon as possible." Delivery was made on August 16, 1944.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF CONTRACTS - (Con't.)

Twenty-eighth Order - (GO 528510) - 13,045 pieces

Another "clean-up" order closing out a number of parts, this was received on September 21, 1944. Included were:-

200 Countersink Screws; 900 Lock Screws - (small); 2,500 Keys -- (closed out at 2,427 on March 16, 1945); 2,875 Pivot Pins -- (closed out at 2,888 on April 17, 1945); 4,100 Pin Screws; 2,050 Sleeves, and 450 Pivots - (keyed). All shipments were made in 1945.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Sub-contracted to WABCO - (654 pieces and 263 heat-treated pieces).

The order originally called for 420 Handles - (small), and 255 Handles - (large), both to be completely machined, together with 320 forgings for the large Handle to be heat-treated only. The small Handles were shipped January 3, 1945. The order for the larger Handles was cut back to 234, these being shipped January 1, and April 20, 1945. The order for heat-treated forgings also was cut back -- to 263 -- and this number was shipped December 6, 1944.

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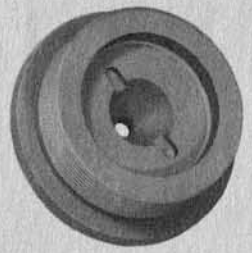
TRIGGER SHAFT
C-8669



BUSHING
A-21299

SLEEVE
A-8384

TRIGGER FORK
A-12132

PIVOT (KEYED)
A-21091

105 MM. HOWITZER PARTS (PLATE IV)

HISTORY OF CONTRACTS - (Con't.)

Twenty-ninth Order - (GO 528570) - sub-contracted to WABCO

This order -- calling for 23 large Handles and 10 Levers -- was received by the Company on September 27, 1944, and sub-contracted in entirety to WABCO. The order for the Levers was later cancelled when it was found they had been ordered in error. The Handles were shipped on January 11, 1945.

- - -

Thirtieth Order - (GO 528571) - 5,914 pieces

Also received September 27, 1944, this order was filled, partly by the Company, partly by WABCO. It called for:-

1,184 Lock Screws - (large), the order being closed out at 1,234 pieces, with shipments between December 13, 1944 and March 16, 1945.

690 Lock Screws - (small), the order being closed out at 665 pieces, with shipments between December 13, 1944, and January 3, 1945.

550 Countersink Screws, shipped between December 13, 1944, and January 3, 1945.

555 Keys, the order being closed out with a shipment of 105 Keys on January 18, 1945.

645 Pivot Pins, the order being closed out with shipment of 60 pieces on December 13, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY - Thirtieth Order - (Con't.)

670 Pin Screws, the order being closed out at 220 pieces on December 13, 1944.

615 Plug Screws - (large), the order being closed out in the amount of 1,255 pieces, with shipments between December 20, 1944 and March 27, 1945.

550 Pivots - (keyed); closed out at 210 pieces, with shipments between December 13, 1944 and January 3, 1945.

1,280 Trigger Forks; closed out at 880 pieces, with shipments being made between January 25, and March 28, 1945.

585 Trigger Shafts; closed out at 735 pieces, with shipments between January 18, and March 28, 1945.

- -

Items calling for 535 Sleeves and 25 Sears were cancelled complete on January 9, 1945.

- -

Also included was an order for 600 feet of cold rolled bar stock from which the Firing Pin Holder Sleeves were machined. The first shipment, of 130 feet, was made December 9, 1944, the last, of 260 feet, on March 14, 1945.

Sub-contracted to WABCO - (1,752 pieces - 386 heat-treated parts).

That part of the Thirtieth Order sub-contracted to WABCO called for:- 282 Catches, this being closed out at 92 pieces on January 4, 1945; 1,300 Firing Pin Holders, this being closed out at 72 pieces on March 6,

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY - Thirtieth Order - (Con't.)

1945; 278 Firing Pin Holder Sleeves, this being closed out at 276 on January 17, 1945; 615 Handles - (small), this being closed out at 400, with shipments between January 3, and 17, 1945; 735 Extractors, this being closed out at 728 in January, 1945. An order for 184 Levers was filled complete on December 7, 1944.

- -

On an order for 625 Extractor forgings, to be heat-treated only, WABCO was able to ship only in the amount of 386 pieces, these being forwarded on October 26, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Thirty-first Order - (GO 529040) - sub-contracted to WABCO

Dated October 6, 1944, this order for 1,031 Levers, was sub-contracted to WABCO. Ten days later the order was cut back to 530 pieces. The first shipment was made December 12, 1944. WABCO made a total of 599 Levers in all, the overage being accepted by the prime contractor, and the final shipment went forward February 7, 1945.

- - -

Thirty-second Order - (GO 529555) - 1,050 pieces

Calling for 1,050 Lock Screws - (large), this order was received on October 17, 1944. They were to be shipped at the rate of 350 pieces

HISTORY - Thirty-second Order - (Con't.)

each month during December, 1944, and January and February, 1945. Five hundred pieces were shipped December 26, 1944, the remaining 550 going forward between January 19, and 25, 1945.

- - -

Thirty-third Order - (GO 530270) - sub-contracted to WABCO

This order -- received October 27, 1944 -- was sub-contracted to WABCO. It called for 525 Handles - (small), to be shipped during December, 1944, and January, 1945. The first shipment went forward on January 17, 1945. The last, on March 23, 1945.

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Thirty-fourth Order - (GO 533000) - 578 pieces

Calling for 578 Keys, this order was received December 29, 1944. The shipments -- completing the order in full -- were made on February 3, and March 24, 1945.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF CONTRACTS - (Con't.)

Thirty-fifth Order - (GO 536065) - 180 pieces

Inquiry regarding production of an additional 850 Keys was made of the Company on January 29, 1945. This was followed by a quotation on February 13, the order being received February 21. On April 29, the order was cut back to 623 pieces, while on May 9, the prime contractor sent a telegram requesting cancellation of the entire order as the order for Howitzers had been cancelled. However by this time a total of 180 Keys had been shipped, and the order was closed out at this figure. Lack of material had delayed production of the items, as well.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Thirty-sixth Order - (GP 536066) - 9,391 pieces

Based on the same inquiry and quotations as the Thirty-fifth Order, this order likewise was received by the Company on February 21, 1945. It called for a number of items, the quantities on which were changed at various times, some items being called for in larger amounts than in the original order, others in lesser quantity. The quantities and the amounts shipped are given on the next page:-

HISTORY - Thirty-sixth Order - (Con't.)

Lock Screws - (small), 1,475, closed out at 1,414 pieces, final shipment being made April 27; Leveling Plates, 1,575, closed out at 1,330, and Countersink Screws, 1,090, closed out at 440 pieces, both on April 27. Also:- Crossheads, 1,205, closed out at 454 pieces, with shipments between May 11, and July 3, 1945; Keys, 1,386 pieces, closed out at 1,382 pieces, with shipments between April 30, and May 22, 1945. Likewise:- Pivot Pins, 1,290, closed out at 1,321, shipments being made between April 30, and July 3; Pin Screws; 1,281, shipped complete between May 11, and May 22; Sleeves, 860 closed out at 818, with shipments being made July 3; Bushings, 900, but later cancelled complete; Detents, 890, but closed out at 70 pieces on April 27; Pivots - (keyed), 1635, but closed out at 340, on April 27; Trigger Forks, 1,685, closed out at 446, with shipments between June 14, and July 6, and lastly, Trigger Shafts, 1,150, closed out at 95, with shipment on April 25, 1945.

- - -

Thirty-seventh Order - (GO 1890) - 915 pieces

This was the last order received from the United Engineering & Foundry Company. Received March 27, 1945, it called for 1,310 Plug Screws - (large). On April 10 the order was cut back to the total of the 915 pieces then completed. These were shipped April 23, 1945.

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Pittsburgh Ordnance District Contract for Firing Pin Holders:-

As mentioned on Page 98, a total of 6,600 Firing Pin Holders, was produced by WABCO on a sub-contract from the Company, which had been given the order for the parts by the Pittsburgh Ordnance District. The order was received by the Company on June 22, 1942, based on an inquiry received June 13, and quotations made on June 16. Since these pieces were already being produced by WABCO for the Company on the United Engineering & Foundry Company orders, the production of these items was turned over to WABCO. The pieces were to be sent to Watervliet Arsenal, Albany, N. Y., packed for export shipment. The first shipment was made on March 20, 1943, the last on May 1, 1944.

* * *

Orders from Cowdrey Machine Division, American Type Founders, Inc.:-

On July 26, 1944, the Company received an inquiry from the Cowdrey Machine Division, of American Type Founders, Inc., Fitchburg, Mass., regarding production of Extractors. Quotations were made July 31, and on August 8, the Company received an order for 1,425 Extractors. The delivery of the first 50 was to be made in September, 1944, with the final shipment of 250 pieces in April, 1945. -- (See also first paragraph, Page 98).

Since the Company had also sub-contracted the production of this part to WABCO, this order likewise was turned over to WABCO, under date

of August 16. The first shipment -- of 60 Extractors -- was made on October 24, 1944, with another 60 pieces going forward on October 27. This was followed by a third shipment of 60 pieces on November 23. The forgings, from which the Extractors were machined, were to be furnished by American Type Founders, Inc., and there was some delay in their procurement which, in turn, held up production.

The order was closed out in the amount of 1,415 pieces in all -- or 10 less than the amount of the order -- with a final shipment of 125 Extractors on April 3, 1945.

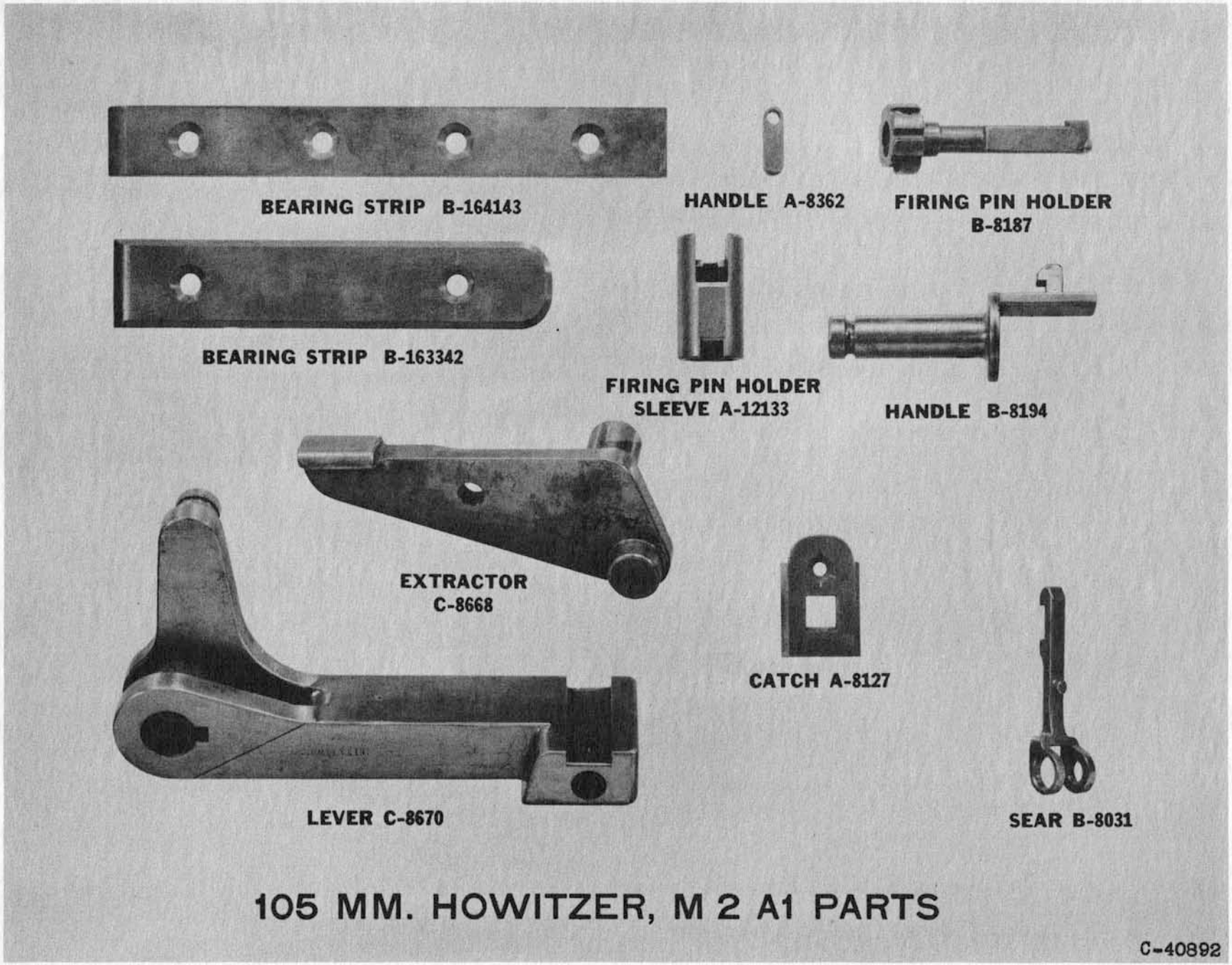
PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

On September 26, 1944, another order was received by the Company from American Type Founders, Inc., for an additional 250 Extractors. The first shipments were to be in the amount of 80 pieces by December 15, with shipments of 85 each on January 3, and February 1, 1945. This production also was turned over to WABCO.

Lack of forgings again delayed shipments so that the first one -- in the amount of 62 pieces -- was not made until April 3, 1945. This was followed by 162 more Extractors on April 17. At this time no more forgings were on hand, so that the order was closed out in the amount of the 224 pieces already shipped.

* * *


BEARING STRIP B-164143
HANDLE A-8362
FIRING PIN HOLDER B-8187
BEARING STRIP B-163342
FIRING PIN HOLDER SLEEVE A-12133
HANDLE B-8194
EXTRACTOR C-8668
CATCH A-8127
LEVER C-8670
SEAR B-8031
105 MM. HOWITZER, M 2 A1 PARTS
C-40892

PARTS AND MANUFACTURING OPERATIONS:

Many of the parts produced by the Company required great care in the machining, and on many, the tolerances were exacting. A brief description of the parts, processes, and some of the difficulties met with in their manufacture, follows:-

Trigger Fork:

Made from a forging, this piece had a 7/16" square broached hole in the center that had to be held to within .0005" of the centerline to which the rest of the contour was worked. The contour -- in turn -- had to be held to a tolerance of .002" from the centerline. After the piece was machined, it was case-hardened -- (cyanide bath at 1450° temperature, followed by oil quenching, this developing a .010" case for wearing properties). After the case-hardening the part then had to meet a Government receiving gage that checked 42 dimensions.

It developed that the Trigger Forks that were capable of meeting the gage test before case-hardening, frequently failed to do so after this treatment. Consequently the Company had to devise tables of anticipated changes in measurements that took place as the result of case-hardening. The achievement was considered outstanding -- not only by Government inspectors, but also by the prime contractor -- and the Company was congratulated on the excellence and uniformity of the part.

- - -

Trigger Shaft:

This piece, in manufacturing treatment and in the rigid tolerances demanded, was similar to the Trigger Fork -- (described above).

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

Bushing:

Made from Nickel steel, this piece was machined to 2 3/4" diameter, and had to conform to a rigid tolerance of .002" in overall thickness. Also a 2.200" - 16NS thread, had to meet the requirements of a Class III fit. The thread also had to be truly concentric with a flange, so that it would go into a recess bored in the Breech Block of the Army Howitzer. In addition the Bushing had a 60° con-shaped recess in one side that had to be polished.

- - -

Crosshead:

This piece was made from manganese bronze which had been cast into a cylinder, turned and faced. A section was parted from the cylinder on a boring mill, this section then cut into segments on a milling machine, and all corners radiused. The segment then was drilled and reamed, with the center hole held to a tolerance of .001" from the center of the block.

- - -

Sleeve:

Made of cast aluminum, this was a pear-shaped piece, with a flare at the stem end. It was formed on a turret lathe, after which a hole was drilled and reamed in the center of the lower face to a depth of about 1½".

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

Pivot - (keyed):

Machined from nickel steel, this piece near one end, carried a key that was an integral part of the parent metal. Special milling and grinding tools were required for the manufacture of this part. These special tools were designed and made by the Company. After the piece was machined, it was case-hardened, and then had to fit a Government gage, which allowed but .002" tolerance on the four dimensions it checked. At the end of the piece opposite to that near which the key was formed, were two flanges. One was radiused on all surfaces. The other -- the end flange -- was knurled to provide a gripping surface.

- - -

Pivot - (slotted):

This piece -- 4½" in length with a diameter of 9/16" -- had three turned surfaces that had to be held to within .0005" tolerance, with the surfaces truly concentric with each other. One difficulty in the manufacture of this piece was encountered in the center-turned section. There a slot -- 5/32" wide, by 5/8" long -- was profiled out. It was in this slot that the Key -- (see below) -- was fitted.

- - -

Key:

After being ground to size for width and length, this part had two sides radiused, and then was case-hardened.

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

Detent:

This part was turned from a drill rod. The turned portion was approximately 1¼" in length, and had a radiused point.

- - -

Lock Screw - (small):

Made from steel, on a hand turret lathe, this part carried a hex head. It also had a die-cut thread with a Class III fit. The thread had to be truly concentric with the other turned surfaces. The balance of the piece also was turned, and the end radiused.

- - -

Lock Screw - (large):

Almost identical with the piece described above -- except in size -- this also was made on a hand turret lathe. The piece also had a hex head, and a die-cut thread with a Class III fit, but at the front on the turned end, there was a taper portion that had to be held truly concentric with the thread.

- - -

Firing Pin:

Turned on a screw machined, this piece was polished. The head was ground square with the turned portion after the piece had been heat-treated. Tolerances were rigid on this piece.

- - -

Firing Pin Bushing:

Made from WD 1095 Steel, this bushing was completely machined and heat-treated, after which a center hole had to be lapped to a plug gage

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

fit having a tolerance of only .0005". There were two threads cut on one end of the piece, together with a flange. Then at the other end the piece was turned to a 60° cone with a rounded end. Two flats also were installed on the 60° cone, these being for assembling purposes.

- - -

Pivot Pin:

This piece was made on an automatic screw machine, being completed on a hand machine. It required a marking-off finish on a 60° angle point at one end. The blunted point of the pin was radiused.

- - -

Leveling Plate:

Made from nickel silver, this was a circular piece with a saucer-shaped indentation on one surface. It was made on a screw machine and an excellent surface finish was required.

- - -

Countersink Screw:

Made from aluminum bronze, this piece was extremely difficult to machine. Difficulty was experienced in obtaining a Class III fit for the 3/8" - 24 thread.

- - -

Retainer Screw:

This part -- made from nickel steel -- was made on a hand screw machine. The head flared from the shank, as in the case of other countersink screws -- the piece then being turned down to form a 1/8" spindle which was used for the retainer portion in the Crosshead. Some difficulty was experienced at first in maintaining a straight 1/8" spindle.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

Pin Screw:

Threaded at one end, and with the threaded end slotted, this piece was turned. One diameter was held at the base of the threaded portion, with the other -- and smaller -- diameter forming the pin portion of the screw. The pin portion was radiused to a rounded end.

- - -

Plug Screws - (large and small):

These two pieces were made from carbon steel on an automatic screw machine. The small piece was threaded for the greater portion of its length, there being an unthreaded portion at one end that was cut square with the centerline. The larger Plug Screw not only had a larger diameter, but was threaded its entire length and slotted at one end. Both pieces were produced without any difficulty.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

* * *

Apart from the rigid tolerances that had to be observed, and the frailty of some of the parts, the only problems that arose were in the machining of the various steels from which the parts were made. There also were changes in measurements due to heat-treatment or case-hardening of some of the pieces that were encountered.

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The Company, being among the pioneer producers of these parts, had to design and make its own special tools, as well as work out the tables of the changes that would occur in the metals during, or following, heat-treatment or case-hardening.

* * *

The manufacture of the various parts called for skilled labor in a number of the departments. Originally, all machining operations were performed by skilled men operators. When male labor became scarce -- due to loss to Selective Service, or through voluntary enlistment -- women were trained to operate various of the milling machines, and to perform hand-grinding operations.

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No reference is made in this report to the manufacturing operations or difficulties encountered in the production of the nine parts that were sub-contracted by the Company to the Westinghouse Air Brake Company. This is because the work was not produced in the Company's plant, although it was produced on the Company's orders.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

PARTS FOR M-3 MEDIUM TANKS

(Lima Locomotive Works Orders)

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Items Produced Included Gudgeon Pins, Nuts, Bolts and Supports -- Material Shortages Delayed Production -- Parts Passed All Interchangeability and Assembly Tests

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A number of parts used on Type M-3 Medium Tanks, then being manufactured for the British Government by the Lima Locomotive Works, Lima, Ohio, were produced by The Union Switch & Signal Company during the latter part of 1941 and up the the middle of 1942, under sub-contracts from the prime contractor. The item produced in the greatest number was the Gudgeon Pin. This was used as an axle for, and also to hold, the bogie wheels in the treadle of the tanks.

A lack of steel resulted in an order for 4,800 Gudgeon Pins being closed out in the amount of 4,298 pieces. The other items -- all produced in the full amount of the orders -- were 800 Bolts, 800 Nuts and 400 each of two types of Support.

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Inquiries regarding production of these parts -- and in addition some 400 Pawls -- were received by the Company on August 8, 1941. Quotations were made August 22, and on August 29 an order for the six items was received. The schedules called for first deliveries by October 1. On October 7, however, the order for the 400 Pawls was cancelled, the Company being reimbursed for expenses incurred.

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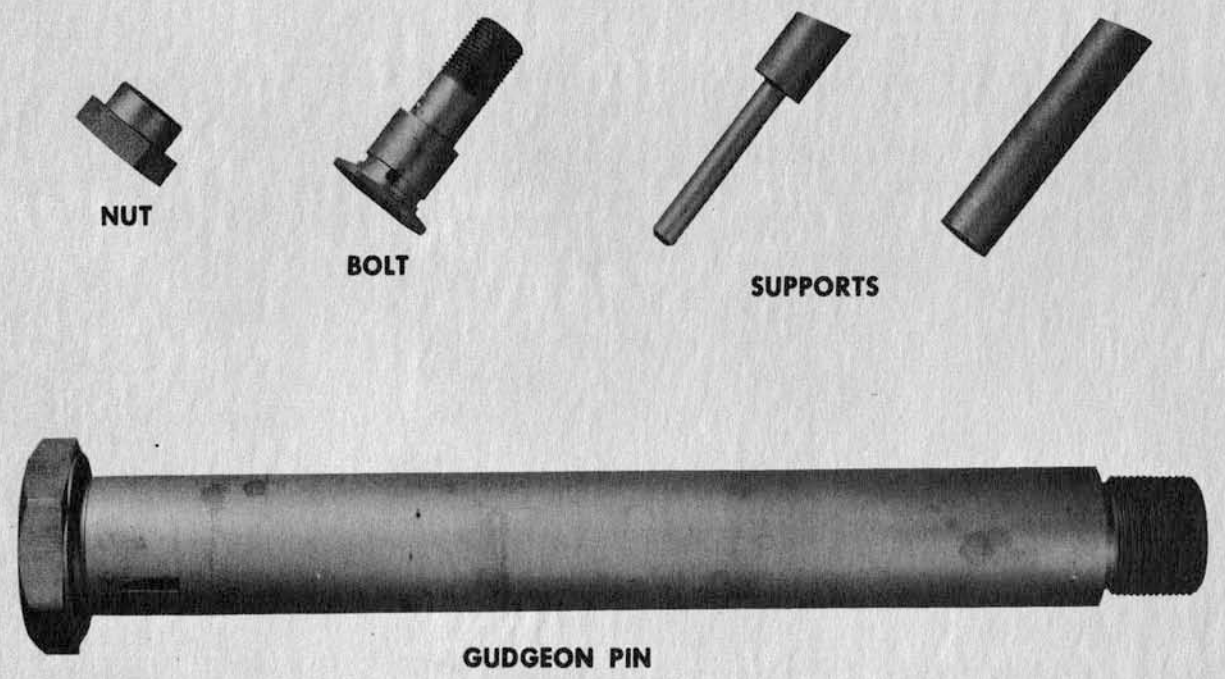

PARTS FOR TYPE M-3 MEDIUM TANK

Lack of tools and supplies held up production of the ordered items, with the result that the first shipment of Gudgeon Pins was not made until October 31, while shipment of the other parts was not made until November 8, 1941. The last shipment of Gudgeon Pins went forward on July 25, 1942. The last shipment of Bolts was made on August 11, 1942. All of the Nuts and 400 of one type of Support had been shipped by November 15, 1941, together with 384 pieces of the other type of Support. The final 16 pieces on this order, however, were not shipped until August 11, 1942.

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Shortages of material was the chief reason for delay in completion of the orders on schedule. For ten days in January, 1942, the Company was without any of the 2 3/8" hex steel bar from which the Gudgeon Pin was machined. Then -- with the consent of the prime contractor -- steel tubing with an outside diameter of 2 3/4", and an inside diameter of 3/4", was substituted.

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Late in 1941 the tanks no longer were being manufactured directly for the British Government, but were being made for and supplied by the United States under Lend-Lease. Still later the tanks were being made directly for use by the United States Government.

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MANUFACTURING OPERATIONS - Gudgeon Pins:

Twelve foot lengths of 2 3/8" hex steel bar stock were converted into Gudgeon Pins in the following sequence of operations:-

(1) Cut bar to 15½" lengths and heat-treat; (2) center both ends; (3) rough turn; (4) turn 1/64" shoulder on head, and undercut; (5) chamfer 15° on end; (6) drill to one-half length on turret lathe, turn diameter for 1½" - 12-thread, thread and undercut; (7) drill other end to one-half depth, re-drilling end for 1" - 8-thread, tap, face head of bolt and chamfer; (8) rough grind; (9) finish grind; (10) mill keyway; (11) drill four ¼" holes; (12) file burrs from hex head, keyway and holes and stencil.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Because of the hardness of the steel bar stock used -- (3½% nickel, 40% carbon, heat-treated to a Brinnell hardness of 239 to 321) -- it was difficult to machine. At first many tools were ruined, but then the Company adopted tungsten carbide tools for the job. Although not recommended for making hexagonal cuts, the method worked out by the Company for using these tungsten carbide tools was found to be completely satisfactory.

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MACHINING OPERATIONS - (Con't.)

Machining of the cylindrical portion of the Gudgeon Pin presented another difficulty in that the specific tolerance was only .0008". Turning the hexagonal head of the Gudgeon Pin also was difficult because of the accuracy that had to be observed. However, the methods adopted by the Company permitted turning at the rate of 110 surface feet a minute.

* * *

Existing machinery in two departments of the Company's plant at Swissvale was used to perform the various operations on the Gudgeon Pins, Nuts, Bolts and Supports. During full production on the Gudgeon Pin, at the rate of 100 a day, the services of only about a dozen men were needed. All were experienced in the use of the machines needed.

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It was reported to the Company that all interchangeability and other assembly tests of the Gudgeon Pin and other items it had produced, had been met by its product in every respect, and the prime contractor commended the Company for the quality of its work on the items.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

OUTER SHELLS - FRONT MANDRELS

OUTER AND INNER COLLARS

(Parts used on 20 MM. and .50 Caliber Machine Guns)

(Edgewater Steel Company Contracts)

--o--

Company's Manufacturing Methods Commended by Air Corps' Inspectors and Prime Contractor -- Special Boring, Threading and Brazing Methods Developed by the Company -- Every Schedule Met After Manufacturing Procedure Determined -- Contracts Ran for Two-and-a-Quarter Years

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During the twenty-seven-and-a-half months from October 23, 1941, to December 4, 1943, The Union Switch & Signal Company produced a number of parts used on 20 MM. and .50 Caliber Machine Guns for the Army Air Forces and the United States Navy. These parts were manufactured under contracts from the Edgewater Steel Company, Verona, Pa., which manufactured and assembled these guns.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

These parts consisted of Outer Shells, or recoil spring housings; Front Mandrels, also known at one time as Barrel Sleeves, and used on a certain type adapter for 20 MM. Guns, and both the Outer and Inner Collars, also used on 20 MM. Automatic Gun mounts. A total of twenty-one orders in all were filled, of which fifteen were for the production and shipment of 216,086 Outer Shells.

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Deliveries of the Outer Shells averaged 8,471 pieces a month during the life of the contracts, although a total of 14,655 pieces were shipped during one calendar month.

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On the other items a total of 25,196 Front Mandrels were shipped between October 29, 1942, and February 5, 1944; Outer Collars in the amount of 9,039 pieces were shipped between May 12, and December 18, 1943, and 9,385 Inner Collars were shipped between October 29, 1942, and December 9, 1943.

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During the production of the Outer Shell, the Company devised a number of techniques to overcome difficulties encountered by other facilities producing the same item. These had to do with the threading and the boring of the tubing from which the Outer Shell was made, and also in the brazing of steel lugs -- or bosses -- on to one end of the Outer Shell.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Representatives of other producing facilities visited the Company to inspect its methods of manufacture of the item. At one time inspectors from the Army Air Forces came to the plant in Swissvale, with a view to changing methods of manufacture so as to overcome the chief difficulties encountered by other facilities. After observing the Company's manufacturing operations -- and making physical laboratory tests without revealing any failures -- the Air Forces representatives instructed the Company to proceed under the methods it had developed.

The prime contractor was so pleased with the quality of workmanship on the Outer Shells that additional contracts were urged upon the Company. These included orders for other items, some of which were accepted by the Company.

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In taking on the contracts for the Outer Shells, no additional construction was necessitated, some 10,000 square feet of floor space, formerly devoted to switch manufacture, being allocated to the new production. No additional machinery was needed. The tools, jigs and fixtures were supplied by the Company, but were paid for by the prime contractor.

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Originally men experienced on lathes and other machines were assigned to the Outer Shell contract. As production was speeded up new men were hired. Many of these men had no previous machine shop experience. The various operations in the manufacture of the Outer Shell were graded as to difficulty, and each man was made familiar with one operation at first, then with others so that, when experienced men were inducted into the armed services, production still was maintained. So proficient did the men become in their tasks that they asked the Company to secure additional contracts for the Outer Shell, "because we have this job licked."

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS -- Outer Shell:

First Order. The Company received an inquiry from the Edgewater Steel Company on August 26, 1941, regarding production of an Outer Shell, or recoil spring housing, for 20 MM. and .50 Caliber machine guns, used on certain types of fighter planes by the Army Air Forces. A quotation was made September 8. Two days later a purchase order for 20,000 pieces was received. The schedule called for shipment of 2,250 pieces a month, to start "as soon as possible."

The Outer Shells -- as pilot pieces -- were shipped on October 23, the last shipment on the first order going forward on May 9, 1942. Peak shipment during any one month on this first order, was in the amount of 5,200 pieces. The Company was advised by the prime contractor on March 7, 1942, that the Air Corps had requested that production go on a 24-hour, seven-day, basis. The first order was completed about two-and-a-half months ahead of the schedule originally set up.

Second Order. Early in 1942 the Company received another inquiry on production of the Outer Shell and immediately made quotations. On February 27, 1942, a purchase order for 20,000 pieces was received, to be shipped at the rate of 4,000 a month after April 15. The first shipment was made May 9, while the last went forward on July 25. Peak shipment in any one month, was 9,550 pieces, or more than double the amount called for under the schedule.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Third Order. Also for 20,000 pieces, this order was received on June 15, 1942. It called for 4,000 pieces monthly after September 15. The first shipment -- of 3,550 shells -- was made July 31, a month-and-a-half ahead of schedule. The order was completed September 19, peak monthly shipments being in the amount of 10,225. The order was filled a little less than five months ahead of schedule.

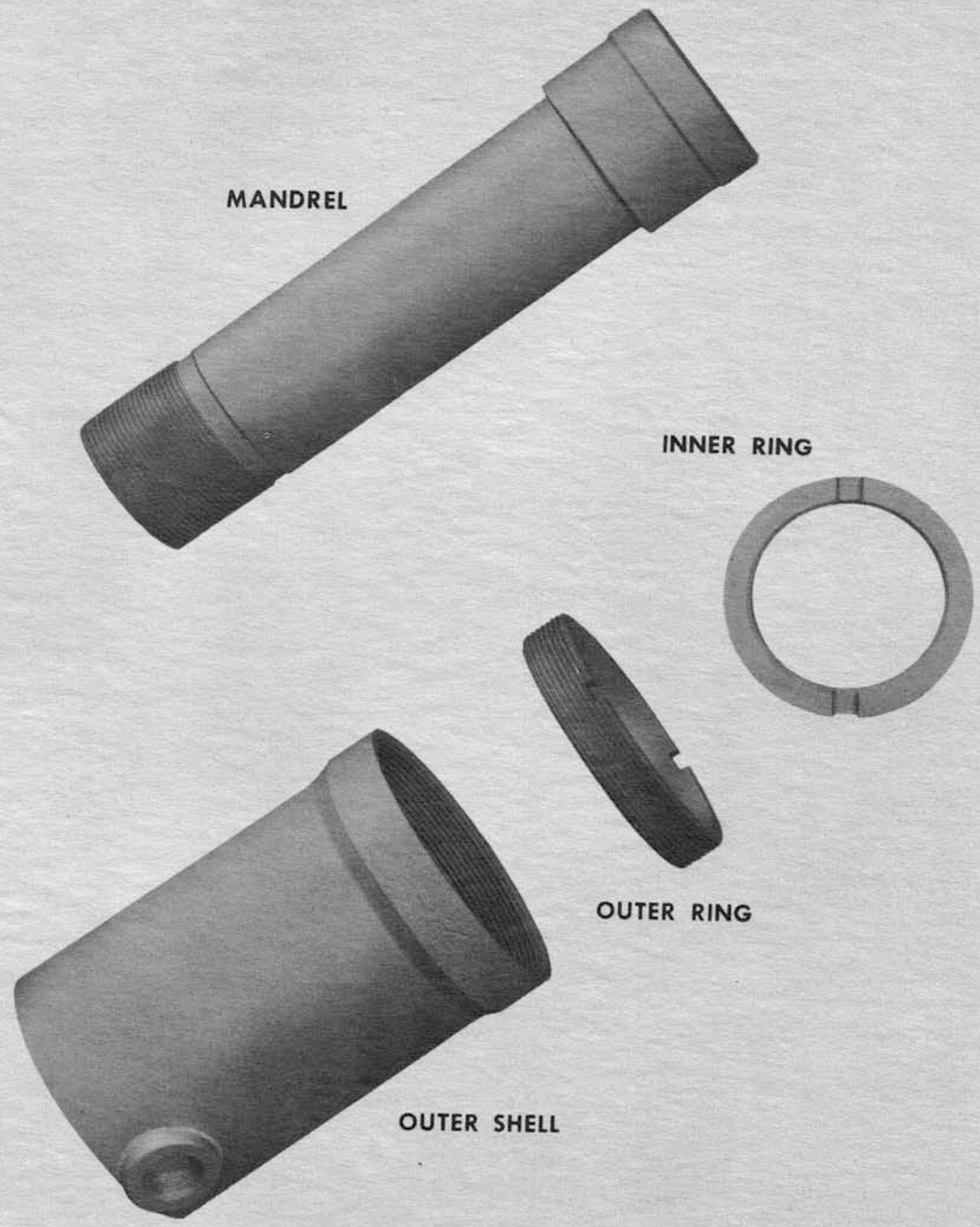
Fourth Order. Received July 28, this called for 15,000 Outer Shells. These were shipped between September 19, and October 24, 1942.

Fifth Order. Shipment of 40,000 Shells, at the rate of 10,000 a month commencing in October, 1942, was asked for in this order, received September 25. The first shipment was made October 29, the last on January 15, 1943. Peak monthly shipments totalled 14,655.

Sixth Order. This was for 20,000 Shells -- to be shipped "as soon as possible" -- and was received December 24, 1942. Shipment of the entire amount was made between January 15 and February 25, 1943.

Seventh Order. Another 25,000 Shells were ordered on January 25, 1943, these to be shipped "as soon as possible" after the conclusion of shipments on the previous order. It was filled between February 25, and May 28.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY



RECOIL HOUSING FOR 20 MM. AND 50 CAL.
AUTOMATIC MACHINE GUNS (AIRPLANE)

Eighth Order. To be completed within two weeks after conclusion of shipments under the Seventh Order, this called for 2,500 Outer Shells. Received on April 1, 1943, it was filled complete in eleven days, between May 28, and June 8, 1943.

Ninth Order. Calling for 15,000 Shells, this was to be shipped within two months after conclusion of the Eighth Order. It was received on April 27, 1943, and shipments were made between June 8, and July 21, 1943.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Tenth Order. Received on May 20, 1943, this entire order -- for 25,000 Outer Shells -- was to be shipped within six weeks after final shipment on the Ninth Order. The first shipment was made on July 13, -- a week before the date called for. Up to September 30, a total of 24,939 Shells had been shipped and the order was closed out at that figure. By agreement with the prime contractor, however, some replacement pieces were shipped December 4, 1943, bringing the total up to 25,000 pieces, and the order was re-instated and closed out at that amount.

Eleventh Order. On June 17, 1943, the Company received an order for an additional 5,000 Outer Shells, to be shipped within two weeks after completion of shipments on the Tenth Order. The entire amount was forwarded, however, between September 8 and 14, 1943.

Twelfth Order. Two days after receipt of the Eleventh Order, the Company received another, this for 13,500 pieces. These were to be shipped within a month after completion of the previous order. On August 6, 1943, however, the prime contractor advised that some orders placed had been cancelled, and that the number of Shells on order would be cut back to 1,500 from 13,500. The latter number were shipped by the Company between September 20 and 25, 1943.

Thirteenth Order. An additional 2,000 Outer Shells were ordered on July 5, 1943, to be shipped within a week after conclusion of the Tenth Order. Shipments were made September 18 and September 22, 1943.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Fourteenth Order. Again calling for shipment after conclusion of the Tenth Order, this was for 3,600 Outer Shells, being intended for use by the United States Navy. All previous orders had been for Air Forces use. This order was received August 30, 1943, and shipments were made between September 3, and November 20, 1943.

Fifteenth -- and final -- Order. Received on October 1, 1943, this called for 3,500 Outer Shells for Air Forces' weapons. No schedule of deliveries was set up. On October 28, the Company was asked if it would close out the order at 816 pieces, because of surplus stock being found by the prime contractor during inventory. The Company advised that 1,486 pieces were in work and nearly completed. The prime contractor agreed to close out at this figure and also to pay for extra parts made in anticipation of filling the original or-

der, as well as pay a cancellation charge for work done on other pieces in excess of the number of 1,486 which were to be accepted. The first shipment went forward on November 20, the final shipment, on December 4, 1943, at which time a number of replacement pieces also were shipped to the prime contractor.

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MANUFACTURING OPERATIONS - Outer Shell:

Operations on the Outer Shell -- which was made from hot-rolled, seamless, steel tubing, with an outside diameter of 3.390" -- were:-

(1) Cutting tubing into 10' lengths; (2) rough cut-off to 4 3/4" length; (3) rough bore inside; (4) rough turn outside; (5) drill ½" hole on two sides on unthreaded end and spot-face 1" diameter; (6) braze bosses to spot-faced surfaces and sand-blast exterior; (7) re-form diameter; (8) finish boring 3.125" inside diameter over 3.375" length, and thread; (9) rough bore 2.875" inside diameter, countersinking 1/8" at 45° on unthreaded end; (10) drill 9/16" holes in line -- (plus/minus .002" from centerline)--; (11) spot-face 3 5/8" dimension across bosses; (12) ream holes in line; (13) countersink for threading lead; (14) rough tap on centers; (15) finish grind 2.875" dimension; (16) re-tap by hand, scrape and file all burrs.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING DIFFICULTIES - Outer Shell:

The tubing from which the Outer Shells were machined was found to be soft and stringy and the walls of the finished pieces were thin, being but about 1/8". After the piece was threaded there was some trouble in meeting the gage inspection because of the possible distortion of the housing. A Class III fit on this thread was called for -- (total pitch tolerance of .0025"). The thread was 3 3/16" NS 3. Boring of the piece constituted another difficulty. After considerable experimentation the Company specified carbide tools for this operation, these being capable of boring 3.50 surface feet per minute. In boring the 3.125" dimension, the tool was started at full depth of bore -- (boring being done from bottom of the bore to outside edge). At 19/32" from the edge, the bore was changed to 3.112" in order to obtain the correct minor diameter for the thread.

The 2.875" holes were held truly concentric with relation to the thread by means of a hardened and ground, threaded adapter on the spindle of the grinder used.

The adoption of carbide tools for boring, and the Company's development of its own system of handling the boring and threading operations, were recognized improvements over methods used by other facilities producing this same piece.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

F R O N T M A N D R E L S

(For Type AN - M1 Adapters)
(for 20 MM. Automatic Gun)
(M1 and M2)

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HISTORY OF THE CONTRACTS:

As a result of the Company's record in supplying Outer Shells, the Edgewater Steel Company, on April 22, 1942, asked for quotations on the production of Front Mandrels for a certain type of adapter used on 20 MM. Automatic Guns being produced for the Army. Quotations were forwarded June 8, and on June 10 the Company received an order for machining 5,000 Front Mandrels. (The piece originally was known as a Barrel Sleeve.)

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

To be made from hot-rolled, seamless, steel tubing, to be furnished by the prime contractor, no schedule of shipment was set up. The first order was completed in approximately four-and-a-half months, the first shipment being made October 29, 1942, the last going forward on March 15, 1943.

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Between the receipt of the first and second orders for Front Mandrels for materiel destined for Army use, the Edgewater Steel Company asked the Company to produce 2,000 Front Mandrels, to be used on Navy materiel. The quotation on the first order was to

stand for this order as well. The order was received by the Company on October 15, 1942. The material from which the piece was to be machined was the same as for the Army Gun Mandrel, except it had slightly small outside and inside diameters. Pieces were to be shipped at the rate of 1,000 a month. The first shipment was made on December 30, 1942, while the last went forward February 25, 1943.

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Second Order. Another order for Front Mandrels, to be subject to Army Ordnance inspection, was received by the Company on February 2, 1943. This was for 20,000 pieces, and was received without previous inquiry or quotations. The Company forwarded quotations, however, on March 12. The material for the piece was furnished by the prime contractor but had been changed to the same dimensions as that supplied for the Front Mandrels which were subject to Navy inspection. The first shipment went forward March 23, 1943. On August 14 it was ascertained that no more supplies of material could be obtained and the order was cut back to, and closed out at, 15,000 pieces, being completed with a final shipment December 4.

Third Order. A small additional supply of seamless steel tubing having been secured, the Edgewater Steel Company sent in another order -- for 5,000 Front Mandrels -- on November 11, 1943. Shipment at the rate of 3,000 a month was called for. The first shipment was

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

made on December 18, in the amount of 588 pieces. On February 8, 1944, however, the Pittsburgh Ordnance Department advised that the War Department had given orders to hold up further shipments as the 20 MM. Automatic Gun was being superseded by one of a new design that required a different mounting device. The order, therefore, was closed out at 3,196 pieces, as of that date. It was completed on March 28, 1944, when the Company shipped to the prime contractor 311 completed Front Mandrels; 253 partially completed pieces, and 2,273 feet of steel tubing.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS AND DIFFICULTIES:-

The operations called for the steel tubing to be -- (1) chamfered; (2) roughed and finished; (3) turning groove face; (4) boring; (5) polishing diameter; (6) filing off burrs; (7) gaging; (8) cutting off to length; (9) roughing and finishing; (10) threading; (11) facing off; (12) chamfering; (13) filing off burrs; (14) rough boring 1.807" diameter; (15) finish boring; (16) boring and reaming 1.587" diameter; (17) chamfering, facing and filing burrs.

The major difficulty in production centered about the threading and in maintaining the concentricity of the outside diameter with the threads. These difficulties were overcome much as they were in the production of the Outer Shells.

* * *

OUTER AND INNER COLLARS
(Used on 20 MM. Gun Mounts)

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The Company machined 9,039 Outer Collars and 9,385 Inner Collars, also used on the 20 MM. Automatic Gun Mounts, on orders from the Edgewater Steel Company. The orders -- originally calling for 10,000 of each item -- were received July 1, and July 9, 1942, respectively. The items were to be furnished "as required." Both were made from seamless, steel tubing. Inquiry on production had been made June 2, and quotations were made on both pieces on June 24.

Due to inadequate supplies of the tubing, the Company was told on October 23 to cease cutting any more, to finish what material was on hand, and then to close out the orders at the curtailed figures.

The first shipment of Outer Collars was made May 12, the last on December 18, 1943. The first Inner Collars went forward October 29, 1942, the last on January 29, 1944.

Both items called for machining operations but care had to be taken to secure a smooth inner surface on the Outer Collar, and a smooth outer surface on the Inner Collar, while the surfaces had to be without tool marks.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

37 MM. HIGH EXPLOSIVE SHELL - M63

(Pittsburgh Ordnance District Orders)

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Total of 302,725 Pieces Produced and Shipped in Less Than Three Months -- Company Told by Ordnance Officials It "Produced Best Shell of Type in District" -- Every Production Schedule Met -- No Reports of Firing Test Failures Ever Reported

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On September 3, 1942 -- exactly eight months to the day from the time The Union Switch & Signal Company received its first inquiry on the production of the item -- the first shipment of 37 MM. High Explosive Shell - M63 was sent by the Company to the Jefferson Proving Grounds, Madison, Indiana, for firing tests. Then within the next two months the Company produced and shipped a total of 302,725 pieces under orders from the Pittsburgh Ordnance District. It still had a back-log of unfilled balances of 1,086,825 shells on orders calling for a total of 1,389,550 shells when the Pittsburgh Ordnance District was forced to cancel the contracts.

Disappointment at the enforced cancellation was expressed by the Ordnance District representatives, and the statement was made that the Company "was producing the best shell of the type in this district."

Cancellation -- it was said -- was due to several causes, among them being the necessity of spreading orders among smaller contractors dependent upon the 37 MM. Shell, and the fact that it was felt that the Company had plenty of other war contracts to carry it along.

In connection with its work on the 37 MM. Shell, the Company at no time ever received a report of any failures during firing tests by the Government, of any of the Company-produced shells.

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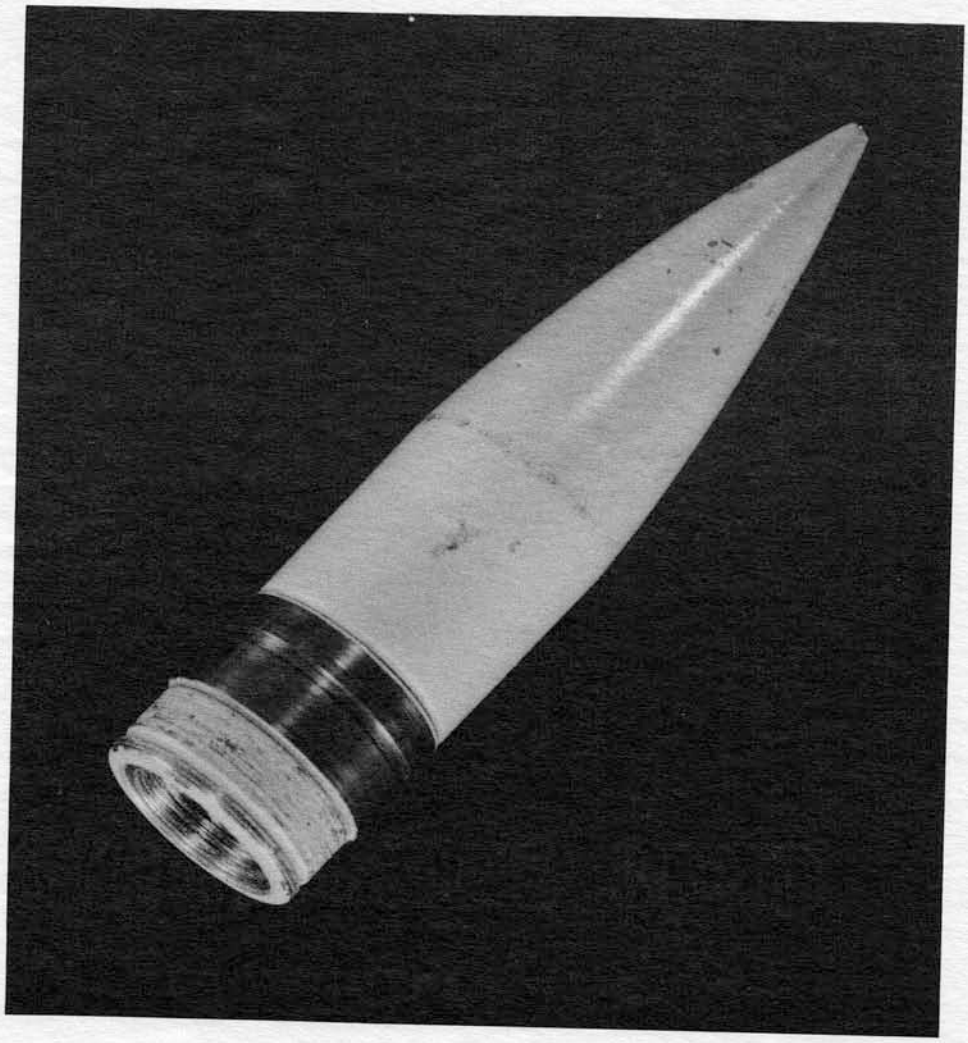

37 MM. HIGH EXPLOSIVE SHELL—M63

HISTORY OF THE CONTRACTS:

It was on January 3, 1942, that The Union Switch & Signal Company received an inquiry from the Pittsburgh Ordnance District regarding the production of the 37 MM. High Explosive Shell - M63. Quotations were forwarded under date of January 7, and 14, accompanied by requirements for the machines needed to produce the item. These machines were to be purchased by the Company, their cost to be returned by the Government over the standard period of sixty months. Advised, on January 29, that it would receive a contract for the production of 300,000 shells, the Company placed orders for steel stock, machinery, tools, jigs, fixtures and other needed items.

Space in the basement of one of the existing buildings -- formerly used as a stockroom -- was set aside for the work. As the machinery was received it was installed in the space provided -- about 40' x 140'. A new concrete floor was laid, and a new lighting system installed. Other improvements also were made.

The formal contract for 300,000 shells was received on April 1, 1942. The same day a Supplemental Order -- calling for an additional 100,000 shells -- also was received.

Even before the Company had made an initial shipment, another order for an additional 660,000 shells, was received. This was on May 13. Then -- on June 27, 1942 -- following a conference between representatives of the Ordnance Department, Ordnance District, and persons representing some 28 other facilities also producing the 37 MM. Shell,

CONTRACT HISTORY - (Con't.)

the Company received yet another order. This one was for 329,550 shells, bringing the total on order to 1,389,550 in all.

The first shipment -- under the first contract for 300,000 shells -- went forward in the amount of 25 test pieces on September 3, 1942. These were sent to a Government proving ground. Then -- on September 11 -- a shipment of 49,075 was made to Ogden Arsenal, Arsenal, Utah, for loading. Daily production averaged 4,500, the record for a 24-hour period being in the amount of 4,875. Other shipments were made in accordance with schedules set up in June, which called for shipments through December, 1943.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

It was on October 30, 1942, that an inventory of shells -- completed and in work -- was requested. This was followed on November 17, by notice that the Government was forced to cancel all contracts with the Company. The final shipment -- made on November 25, 1942 -- was in the amount of 67,425 shells, representing the final shipment on the first order for 300,000, and 2,725 shells on the Supplemental Order for 100,000 shells. The balance of the Supplemental Order was cancelled complete, together with the subsequent orders for 660,000 shells, and 329,550 shells, respectively.

This -- as stated previously -- left unfilled balances of 1,086,825 shells.

* * *

MANUFACTURING OPERATIONS:

Production of the 37 MM. High Explosive Shell - M63, by the Company consisted of the conversion of 1 9/16", cold drawn steel, bar stock, into finished -- but unloaded -- shells packed for shipment to ordnance depots.

The first operation was performed on a battery of four 8-spindle automatic screw machines. On these the outside diameter was formed and shaved; the driving band was finished and knurled, and the piece was further drilled, counterbored, reamed and cut off. Subsequent operations called for:-

(a) Finish turning the nose; (b) grinding contour on centerless grinder with contour-formed wheels; (c) assembling of the gilding-metal driving -- (rotating) -- band, into knurled groove on swaging machine; (d) machining the band; (e) counterboring and tapping; (f) re-tapping; (g) inspection, weighing and stenciling of shell; (h) painting -- with a special orange-yellow paint, and drying, and, (i) packing for shipment.

Seven Government inspectors -- women -- were stationed in the 37 MM. Shell Department during the entire period that the Company was engaged in production of the piece.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS:

The Company experienced little difficulty with this item, and the production techniques employed occasioned nothing but favorable comment. A conveyor-track delivery system which the Company installed, speeded up production, and was of much interest to Ordnance Department officials, similar installations being recommended for installation in other shell-producing plants.

Some delay was occasioned the Company in procurement of certain machines. These included the automatic screw machines, tapping machines, a centerless grinder, turret lathes, etc. From time to time difficulty also was experienced in securing supplies of steel bar stock. Appeals to the Government resulted in the establishment of priorities through which the Company was able to be serviced promptly. It was the inability of the Company to secure these necessary items as promptly as it had expected that was responsible for the delay in the initial shipment of the shells.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Personnel in the department producing the shell consisted of 35 men as machine operators, six laborers, and a painter, while female help included 17 women on the inspection line and two women employed as packers. On most of the machines a triple-turn, seven-day week was maintained.

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TALON, INC., CONTRACTS

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Order for 57 MM. Gun Mounts Partially Filled when Order was Cancelled -- Parts for 75 MM. Howitzer also Ordered but Contract Later Cancelled in Entirety

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On March 2, 1942, The Union Switch & Signal Company received an inquiry from Talon, Inc., of Meadville, Pa., asking for quotations on the production of nine parts for the 75 MM. Howitzer, a piece for the manufacture of which the Meadville concern held a prime contract. The quotations were forwarded March 11, and on March 20, an order calling for the machining of the nine parts -- in amounts of from 1,501 to 4,369 pieces of each -- was received. The parts included screws, firing pins, bushings, pivots, etc. On April 9, however, the Company was advised that the contract for the Howitzers had been cancelled, and that the order in turn would be cancelled complete. An adjustment, covering expenses incurred by the Company in preparing for production, was reached with Talon, Inc.

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A week later the Company was asked by Talon, Inc., to submit quotations on the manufacture of Catches used on 57 MM. gun mounts. These quotations went forward April 24, and on May 14, an order for 1,908 Catches was received. These were to be made from a special grade of steel, and their production called for intricate machining operations. Production was to be started as soon as possible after the Company had tooled up, made the necessary jigs and fixtures and the special steel had been secured.

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Another order, calling for an additional 586 Catches, was received on July 1, while on August 6, a third order -- for another 1,322 Catches -- was received by the Company. This made the total to be produced in the amount of 1,378 pieces.

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Production had been started on the first order, and the first shipment had gone forward on August 27, when -- on September 15 -- all orders were cancelled, the first being closed out in the amount of the 75 Catches that had been shipped to date. A balance of some 95 pieces, nearly complete, was ordered scrapped, and a cancellation adjustment was to be arranged. The explanation for the cancellation was that the Army had changed specifications for the gun mount, rendering the Catch obsolete.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Some fifty Catches which Talon, Inc., returned to the Company on October 2, 1942, as not having been made to certain dimensions, were reworked and -- on August 23, 1943 -- were shipped to the Yoder Company, Ordnance Plant, Gun Division, Cleveland, Ohio, on instructions from Talon, Inc.

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POTENTIOMETERS AND GEAR DRAWER ASSEMBLIES

for

U. S. SIGNAL CORPS RADAR CONTINUOUS SIGHT
(Western Electric Company Contracts)

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Company Pioneered in Manufacture and Assembly of Parts for "Urgent and Critical" Items Used in Plane-Locating Instruments -- All Production Schedules Over Which Company Had Any Control Were Met Despite Continuing Changes in Design and Specifications -- Tools and Fixtures Were Designed by Company -- Miscellaneous Items Also Furnished to Prime Contractor

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Two essential parts of the item known as SCR-547 -- (Signal Corps Radar Continuous Sight, or plane-locating instrument) -- were manufactured and assembled in the Special Development Department of The Union Switch & Signal Company between mid-1942 and the early part of 1943, under contracts from the Western Electric Company, Baltimore, Maryland. These items were two types of Potentiometer, and Gear Drawer assemblies. They were used in the range-finding device better known to the public as the "Mickey Mouse" because of its peculiar shape. The device was being developed jointly by the Western Electric Company and the Bell Telephone Company Research Laboratories, and the utmost secrecy surrounded the item and its component parts. The items produced by the Company were sent to Baltimore for assembly into the complete instrument, which was an adaptation of Radar and which was on the "urgent and critical" list of the United States Signal Corps.

A total of 1,015 Potentiometers, of both types; 400 Gear Drawer Assemblies, together with a number of gear blanks, hinge assemblies, and oil pans and fillers, were produced by the Company on purchase orders from the prime contractor.

Capable of locating aircraft within a range of 20 miles; of projecting the image of the craft upon a screen, and of synchronizing gun-fire upon the aircraft, the SCR-547 -- at the time of production -- was considered to be invaluable during defensive warfare. The

device also calculates the height and speed of the approaching aircraft, transmitting this information to anti-aircraft guns and their crews.

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That the Company figured prominently in the development of SCR-547 into its final form is attested by the fact that it was the pioneer manufacturer of one type of the Potentiometers, and it was the first company to manufacture the Gear Assemblies. The entire unit into which these two items were finally assembled was being re-designed and improved throughout the entire period of manufacture. Some 30 changes were made in the specifications for the Potentiometer, and some 120 changes in the Gear Assemblies. These changes -- ordered in the light of discoveries, or adaptions based on performance tests -- were made while the items were in production.

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The greatest secrecy surrounded the work being done at the Company's plant, and a special form of pass was required to gain admittance to the Special Development Department. Even then certain sections of the Department were barred to any but specially authorized persons within the Department.

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In connection with the Range Potentiometer, the Company was in receipt of a telegram from the Western Electric Company on May 3, 1943, which read:-

> "The first 1B equipment has just been accepted by the Signal Corps, and the management hereby expresses its sincere appreciation to your Company for the fine co-operation we have received in accomplishing this feat."

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS - (Potentiometer):

In June, 1942, after considerable preliminary negotiation, the Company was notified by the Western Electric Company that it would receive an order for construction of the 2B Type Potentiometer. On June 20 a purchase order for an initial 25 of the item was received. These were to be made on a tool room basis. On July 16, the order was increased by 900, with shipment to be made in various amounts until the end of October, 1942.

On September 19, the order was increased to a total of 1,300. Then, on January 27, 1943, it was cut back to 1,282. Finally -- on February 3, 1943, the Company was notified that the 2B Model was to be closed out in the amount of 400. The shipment of the 400 Potentiometers was made between October 14, 1942, and February 25, 1943.

CONTRACT HISTORY - Potentiometer - (Con't.)

Delay in the shipment of these 400 items was due to changes in design or specifications, or because of failure of the Company to receive certain items to be supplied it for assembly within the Potentiometer. The Company was not held responsible for the delays.

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While still engaged in production of the 2B Type, the Company received inquiries regarding production of a newer type -- the 1B. These inquiries were received November 19, and December 1, 1942. A quotation was made December 5 and -- on December 31 -- a purchase order for a total of 613 Type 1B Range Potentiometers was received by the Company. Shipment of the entire 613 was asked for between January 23, and July 23, 1943. These deliveries were made.

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A special order for two Potentiometers of the 2B Type -- to be shipped "as rapidly as possible" was received by the Company on June 5, 1943. These went forward June 11, and brought up to 402, the total number of 2B Type Potentiometers produced.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS ON THE POTENTIOMETER:

Consisting of a 12", circular, steel casting, on which were mounted ten sub-assemblies, the Potentiometer had, in all, some 82 parts. Most of these were furnished to the Company by the Western Electric Company, or were purchased from outside sources, 12 parts in all being made by the Company.

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Five departments -- including the Special Development Department -- worked on production of the Potentiometer. Castings were made and machined at the Company's plant; studs were riveted on the drum in another department, while in still another springs -- used in certain of the sub-assemblies -- were wound.

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An area, some 40' x 60', was set aside in the Special Development Department for production of the Potentiometer. As with all development projects, the Company had to originate manufacturing and assembling procedures. Some fifty-six special tools and fixtures were designed and made by the Company to facilitate the various operations. After the first 25 units had been completed, representatives of the prime contractor were called in, and to the Company fell the task of training these people in practical inspection technique on the item.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - Potentiometer - (Con't.)

There were constant changes being made in the design of, and specifications for the Potentiometer, some of them requiring that certain parts be scrapped. Other changes required re-tooling, the making of new fixtures, and a back-tracking in operations already performed. This contributed greatly to the slowing-up of production but due allowance was made by the prime contractor.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

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As produced by the Company the Potentiometer was complete except for the winding and fitting of a special coil inside the drum-like container. The angular distances for this coil winding were laid out by the Company, the winding being done at the prime contractor's plant in Baltimore. The body of the Potentiometer was made of sheet metal and castings.

Although at the start of production it was not known at the Company's plant, this particular Potentiometer -- one of several entering into the completed unit -- was to be fitted into the Gear Assembly drawer. This was the other item being produced by the Company. Great care had to be observed to hold all distances within very fine tolerances.

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GENERAL REMARKS - Potentiometer - (Con't.)

There were a number of manufacturing difficulties that presented themselves during the period the Potentiometer was produced. On one of the sub-assemblies -- (the Limiter sub-assembly) -- there was a worm-and-nut-cam combination that served to latch and unlatch pawls. Because these pawls had to fit within a tolerance of .002", they required great care in their manufacture. The Company developed its own pawl-cutting tools. These were so successful that the prime contractor urged their acceptance and use by other manufacturers.

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Another Company development was a spiral-wound, flat spring -- made of bronze -- used in the Brush assembly. The Company was asked by the prime contractor to supply these springs to other producers of the Potentiometer.

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Some difficulty in machining also was experienced in the case of the cast iron drum, not only because the material was hard to machine, but because the wall thickness was only 3/16". This drum was 10" in diameter and had to be held within .002" concentricity with the bushing arms.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - Potentiometer - (Con't.)

The production line for the potentiometer was for the most part composed of women, working under a man leader. Each woman completed her own individual sub-assembly, or final assembly. Because of the nature of the device, extreme care was taken to explain to these workers the great need for accuracy.

So proficient did these women workers become that the first Potentiometers produced by the Company differed from the last only in the speed with which it was produced. Representatives of the prime contractor told the Company that the first item it produced was as perfect as the last.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

It also was indicative of the fine work of this all-woman production line that only one Potentiometer produced by the Company, ever was rejected by the prime contractor. This -- simply enough -- was for a loose dowel pin, the repair of which took only ten minutes.

* * *

HISTORY OF THE CONTRACTS - (Gear Drawer Assemblies):

While the Company was preparing to produce the 2B Type Potentiometer, it was asked by the Western Electric Company if it also would undertake production of Gear Drawer Assemblies -- another vital part of the SCR-547. Quotations were given and on July 9, 1942, the Company

CONTRACT HISTORY - Gear Drawer Assemblies - (Con't.)

was informed that it would receive an order for 300 such items. The confirming letter was received on August 20. The prime contractor was to furnish all ball bearings, gears, air condensers, variable speed drives, Selsyn transmitters, Bodine motors, spur-gear differentials, electrical contacts and other items -- including a cast iron base. The latter was to be machined only, by the Company.

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On October 3, 1942, the order for Gear Drawer Assemblies was increased to a total of 700, but on March 12, 1943, this was cut-back to a total of 400. Due to changes in specifications, non-receipt of parts, etc., production delays resulted from time to time, but -- as in the case of the Potentiometers -- these delays were not held against the Company by the prime contractor. Shipments of the item were made between November 14, 1942, and April 27, 1943. In addition, some 97 partially assembled Gear Assemblies were sent forward on February 18, 1943, while 605 Terminals -- (a part used in the assembly) -- were shipped out on March 13, 1943.

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At the time the initial order was received the prime contractor had agreed to furnish the base part castings. However, on October 3, 1942, when the order was increased to 700, the Company was asked to furnish and machine the castings in the amount of 300 pieces.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - GEAR DRAWER ASSEMBLIES:

Consisting of a cast iron base, 18" x 24" x 4", completely machined, on which were mounted two Selsyn transmitters; two Bodine motors; a variable speed drive, and six different gear assemblies, the item known as the Gear Assembly had a steel panel attached to the front of the base. The gear assemblies were interlocked to achieve a gear reduction of 33,000 to 1. The steel panel, which contained various dials, had to be positioned and mounted with extreme care to achieve the desired accuracy. In all some 15 sub-assemblies, containing some 80 parts, were affixed to the front panel. Sheet steel sides further enclosed the base and enabled it to serve as a drawer with which to fit it into its cabinet.

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No new machines had to be installed to produce the equipment, but a fluorescent lighting system was installed. Women were trained to make the individual sub-assemblies, each of which consisted of from to to ten parts provided by the prime contractor. The general assemblies -- (the positioning of the sub-assemblies on the base) -- were made by men. Regular mechanics of the Special Development Department conducted all the experimental work.

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In addition to some small items entering into the assembly, the Company also made the parts for a gear-and-clutch assembly.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - Gear Drawer Assemblies - (Con't.)

The production crew consisted of from 25 to 30 women; 20 men, mostly development engineers, plus those engaged in manufacture or machining of parts, located in other sections of the plant. Space allocated to the assembly lines approximated 1,600 square feet.

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All production schedules were maintained insofar as the Company was able to control them, and the prime contractor frequently complimented the Company on the manner in which it handled the contract. From time to time the Company was able to use its excess production to compensate for slower manufacturing processes in the plants of other facilities producing the same equipment.

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There were no recorded instances of failure of any of the Gear Drawer Assemblies produced by the Company. Rejects -- which ran very high when production was started -- declined to approximately 2% after the crews had been thoroughly trained in the performance of their specific operations.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - Gear Drawer Assemblies - (Con't.)

The Gear Assembly -- as in the case of the Potentiometer -- was being re-designed throughout the period of production. This interfered with regular production schedules. The number of changes in specifications on this particular item ran to about 120.

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Permissable backlash in the entire chain of gears -- after interlocking and final assembly -- had to be held to within .003". One of the chief contributions to manufacturing difficulties was the fact that many of the sub-assemblies the Company obtained from outside sources took advantage of a maximum .002" tolerance. Interlocking of three such gear assemblies, each of which had taken full advantage of the .002" maximum backlash tolerance, confronted the Company with a problem not of its own making, and one which was solved only after considerable trouble and almost constant research.

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The Company designed and produced within the Development Department the fixtures and drill jigs that would provide the needed accuracy in the mounting of the various assemblies, and it was this that made it possible for the assembly crews to overcome many of their most serious problems.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - Gear Drawer Assemblies - (Con't.)

Production work on the Gear Drawer Assemblies was divided among men and women. The number of women making the sub-assemblies was 30 at peak production. Six of these were women transferred from other departments within the plant, but the others were completely unfamiliar with factory work. Insofar as possible, the new women employes were selected from applicants who had members of their immediate families in the armed forces. This was because of the necessity for secrecy surrounding the nature and purpose of the item.

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The men selected to make the general assemblies were -- in the main -- formerly employed as garage mechanics, radio and refrigerator repairmen, etc. They were technically minded but had never worked with precision instruments before. Experienced men in the Development Department trained these new men until they became specialists. The specially designed precision tools provided by the Development Department, made up in great part, for whatever lack of skill existed among the production workers.

* * *

MISCELLANEOUS CONTRACTS FOR PARTS:

In addition to the aforementioned items of major production, the Company also manufactured a total of 137 Oil Pans and Filler Assem-

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MISCELLANEOUS CONTRACTS - (Con't.)

blies for the Western Electric Company, these items being used in the final assembly of the complete instrument. It also received a number of purchase orders for making gear blanks. These blanks -- when produced -- were sent to outside sources for cutting. Some were returned to the Company for use in assemblies, the balance being supplied by the prime contractor to other producers of the items.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

On November 26, 1942, the Company received inquiries about taking on the machining of a total of 1,425 Hinge Assemblies. Five hundred of these were to be shipped to the prime contractor, and 925 to the Johnson Tool & Engineering Company, Dayton, Ohio. Quotations were forwarded and purchase orders covering the amount were received on December 29, 1942. On March 1, 1943, the total ordered was cut back to 375 but since 377 had already been shipped, the order was closed out at that figure.

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A series of purchase orders covering the production of blanks for five different types of gears were received by the Company on October 26, 1942. Some of these orders were filled in full, the others being closed out at different times in different amounts. A table, showing information on these orders, is found on the next page:-

MISCELLANEOUS CONTRACTS - (Concluded)

Part #	Number Ordered	Date Final Cut-back:	Closed Out at:	Shipments Made from:
717542	3,000	2-15-43	757	11-21-42 to 1-11-43
717578	1,000	4-3-43	689	11-21-42 to 2-2-43
717593	2,000	4-3-43	1,088	11-21-42 to 4-14-43
721002	3,000	2-15-43	360	12-11-42 to 3-18-43
721447	2,000	2-15-43	900	11-14-42 to 2-4-43

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.45 CALIBER AUTOMATIC PISTOL - (M-1911-A-1)

(Pittsburgh Ordnance District Orders)

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One of Four Prime Contractors in Nation, Company Provided Army Ordnance Department with Weapon that Received Special Commendation for "Finish" and "Action" -- Total of 55,000 Supplied, None Ever Rejected, Pistol Passing All Government Interchangeability and Firing Tests -- Women, Trained as Production Crews, Did Excellent Job

--o--

Under a direct contract with the Pittsburgh Ordnance District, and as one of the four prime producers of the item in the United States, The Union Switch & Signal Company during the nine months between February 15, and November 27, 1943, produced and shipped to Army Ordnance stations a total of 55,000 automatic pistols of .45 caliber, the item being designated by the Army as M-1911-A-1. This type pistol was adopted by the armed forces of the United States in 1911, being used extensively by the Army, Marine Corps, Air Forces and other fighting units.

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The original contract -- formally awarded on May 5, 1942 -- called for 200,000 pistols. This number was cut back to 30,000 on March 8, 1943. On June 26, 1943, however, an additional 25,000 pistols were ordered. The Company also supplied spare parts and assemblies in the total amount of 130,474, these being furnished under separate contracts. In addition -- during 1944, long after it had ceased to produce the pistol -- it supplied a total of 73,423 forgings for the receiver used in the M-1911-A-1, to the Ithaca Gun Company, Ithaca, N. Y.

Negotiations to produce the pistol began early in 1942 when representatives of the Ordnance Department inspected the Company's facilities for production. Notice of award of the contract was given on April 6, the formal contract being received a month later.

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Following notice of the award, and while the Company endeavored to secure machines, tools, fixtures, etc., a group of twelve men was sent by the Company to the plant of the Colt Patent Fire Arms Manufacturing Company, Hartford, Conn., the chief producer of the pistol. This group remained in Hartford for a fortnight observing and studying production methods and techniques. The men of this group comprised the original supervisory force for the Company, and were charged with training the production crews.

- - -

As manufactured by the Company, the weapon was made up of 54 component parts, eleven of which were completely manufactured in the special department set up by the Company to handle production of the pistol. Five parts -- manufactured elsewhere within the plant -- were finished in this department, while six semi-finished parts obtained from outside contractors were completed in the department as well. The remaining 32 parts -- some of them already assembled -- were purchased from outside sources.

Approximately two floors in an existing building, were set apart for production, while space in another building was set aside for heavy machining operations.

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.45 CALIBER AUTOMATIC PISTOL M1911A1

HISTORY OF THE CONTRACTS:

Following visits by representatives of the Pittsburgh Ordnance District and the Ordnance Department to the plant of the Company early in 1942, a contract for the production of 200,000 of the .45 Caliber Automatic Pistol - M-1911-A-1, was awarded the Company. The letter of intent was dated April 6, 1942, the formal contract being received on May 5.

Upon the return to the Company's plant of the group of twelve men who had been observing manufacturing techniques and procedures in other producing plants, recruiting of production crews was started by the Company. The first shipment of completed pistols was made on February 15, 1943, when six were forwarded to a testing depot. This was followed by a shipment of 3,000 pistols during March, with other shipments -- in increasing amounts -- being made in the following months.

The Company then received notice that the original contract was to be cut back to a total of 30,000 pistols, the formal notice to this effect being received on March 8, 1943. When nearly this total number had been shipped and there was a slow-down in production, together with a breaking-up of the department personnel, an additional 25,000 pistols were ordered. The final shipment of all pistols was made on November 27, 1943.

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CONTRACT HISTORY - (Con't.)

The notice of intent to award the contract for an additional 25,000 pistols was received on June 26, 1943, the formal order being received on July 9. The schedule set up at that time was for 9,500 pistols in July, 12,000 in August, and 3,500 in September. While much of the machinery was still in place, this cancellation-and-resumption of the contract seriously hampered the department's operating efficiency, so that the schedule could not be adhered to.

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In connection with the cut-back from 200,000 to 30,000 pistols, the Company was in receipt of a letter from Major General T. J. Hayes, Acting Chief of Ordnance, which said in part:-

> "With the development of new weapons or new techniques of fighting, changed requirements for weapons often result. * * * This, of course, can explain the necessity for the termination which we are making in this instance. It cannot, however, lessen our regret at having to cause this disruption in your plant, which has to ably assisted us in our work.
>
> " - - - the management and employees of your plant have been our very loyal and efficient supporters. No one would believe for an instant that this termination is for any cause other than a change in the demands for the Cal. .45 pistol. In changing your plant to carbine production, you are now serving what is a more critical need. * * * With renewed assurance of gratitude for the fine job being done for Ordnance by the management and employees of Union Switch & Signal Company and with every confidence in your continued support, I am, etc., etc."

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CONTRACT HISTORY - (Con't.)

When the notice of termination of the contract was received, the Company took on production of parts for the .30 Caliber Carbine. This work is described in pages 223 to 240 of this report. Many workers in the Pistol Department were assigned to work on this new contract.

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On June 6, 1943, two contracts for furnishing spare parts for the .45 Caliber Automatic Pistol were awarded the Company, as the result of negotiations begun on May 12. One was for some 26 parts, to be furnished in varying amounts. The other contract increased the number of pieces wanted of three of the parts, and also called for 8,000 pieces of an additional part. All parts were shipped as of September 15, 1943, a total of 130,474 being supplied.

In addition, the Company also had supplied extra parts and assemblies on the Pistol contracts, in the amount of twenty sets of essential spare parts for every 2,000 Pistols.

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During mid-1944, after the Company had ceased to manufacture the Pistol, it was in receipt of an order from the Ithaca Gun Company, Ithaca, N. Y., for 50,000 forgings of the receiver used in the M-1911-A1 Model Pistol. The requirements were said to be "urgent" and de-

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

liveries rising to 4,000 forgings a week were scheduled. Early in May the Company had received an inquiry, asking for quotations. These were made on June 25, 1944, and a purchase order was received on June 1.

Production was started but in September new dies had to be made, which slowed up the work. A total of 10,041 forgings was shipped in July, followed by 5,261 in August; 8,365 in September; 7,401 in October; 13,406 in November, and 5,256 -- plus an overage of 57 -- in December, for a total of 50,057.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

On August 15, the Company received an order for an additional 16,000 forgings, to be delivered at the rate of 2,500 weekly, after shipments on the first order were concluded. The first shipment was in the amount of 1,000 pieces on December 26, followed by 2,827 on December 29, 1944. The last shipment -- completing the order -- was made on February 22, 1945.

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Even before production had started on the second order -- or the first order had been completed -- the Company received an order for 26,500 more forgings, to be shipped at the rate of 2,500 a week after conclusion of the second order. The first shipment went forward on February 16, 1945, in the amount of 1,728 pieces. The Company had been notified on February 7, that the order would have to be cut back from

CONTRACT HISTORY - (Con't.)

26,500 pieces to a total of 7,750. On February 22, the second shipment, of 4,428 forgings, was made. On February 26 it was found that only material enough to finish 7,366 forgings was on hand. It was agreed to close the order out at this figure, and the final shipment -- in the amount of 12,210 pieces -- was made on March 2, 1945.

* * *

PRODUCTION DIFFICULTIES:

When the contract for production of the .45 Caliber Automatic Pistol was received in the early part of 1942, every effort was made by the Company to go into production as rapidly as possible. There was, however, an uninterrupted series of delays and set-backs over which the Company had no control. Some 658 new machines -- including millers, broachers, shapers, lathes, grinders, knurlers, deep-hole drills, reamers, drill presses and chamfering machines -- were needed. Only a little more than half of the necessary machinery had been received by the Company in November, 1942, some six months after the award of the contract. The Company was forced to divert equipment of its own to the Pistol Department in an effort to get production under way.

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PRODUCTION DIFFICULTIES - (Con't.)

In the matter of tools the Company fared about as well. It was forced to make many of its own tools, jigs and fixtures. Some 421 different types of cutting and drilling tools were needed. By September, 1942, orders for 85% of them had been placed, but only about 9.6% of those ordered had been delivered. By December, only about 85% of the orders had been filled.

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Another factor contributing to delay in production was the non-receipt of certain additional information concerning dimensions for some of the essential parts of the pistol. This was to be furnished by the Ordnance Department. Special fixtures for these parts could not be ordered until all information had been received by the Company. Also -- by December, 1942 -- less than 90% of the special fixtures and gages had been delivered. The Ordnance Department succeeded, finally, in expediting most of the needed items.

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Delays in delivery, both of raw materials and of semi-finished, or fully assembled items, by sub-contractors, was a problem that maintained during the life of the contracts. It improved a little just before the close of production but never was successfully solved, even though the Government established special facilities to aid producers of the Pistol and other small arms.

PRODUCTION DIFFICULTIES - (Con't.)

These were but some of the troubles that befell the Company during the life of the Pistol contracts. As was stated previously, the cut-back caused disruption of the production crews. Many of the workers were absorbed into other departments, and could not be spared for return to the Pistol Department when the contract was again increased.

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A detailed report of the operations performed on the various parts of the Pistol would be voluminous. For instance, the Receiver for each Pistol underwent 106 individual operations, during which some four-fifths of its weight was machined from the original forging.

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The intricacy of the manufacture of the Pistol can be suggested by these facts:- The number of different machining operations performed by the Company on the parts for the Pistol, was 600. These required the services of 658 different machines; 421 types of cutting and drilling tools; 239 different fixtures, and 447 different gages. While the Government owned the machines, gages and fixtures, the Company provided its own perishable tools.

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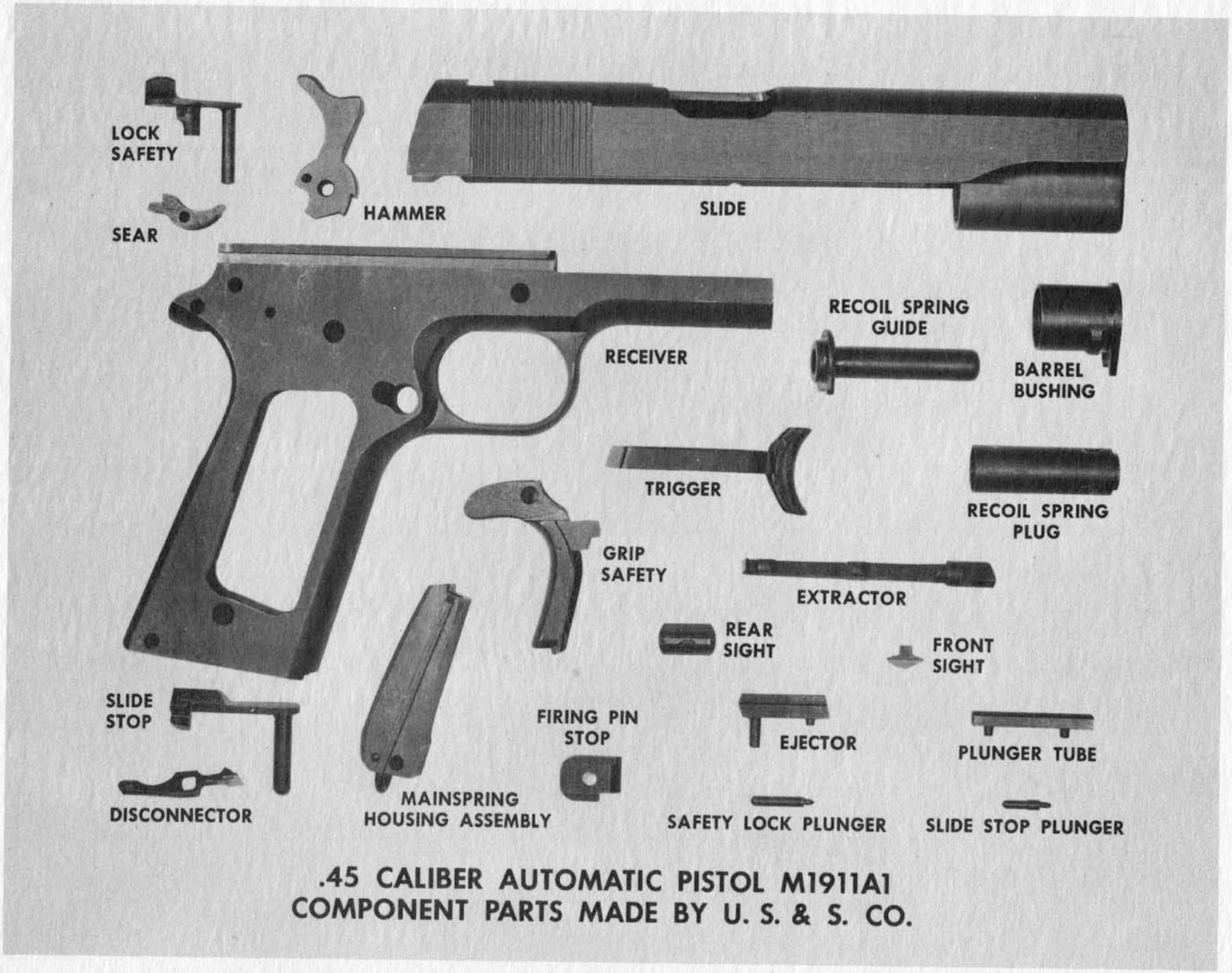
PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY



.45 CALIBER AUTOMATIC PISTOL M1911A1
COMPONENT PARTS MADE BY U. S. & S. CO.

PRODUCTION INFORMATION:

The eleven parts manufactured in entirety by the Company are named in the following table, the figures in parentheses being the total number of operations performed on each:-

Disconnector.	(27)	Mainspring Housing. .	(34)
Ejector	(17)	Plunger Tube.	(12)
Firing Pin Stop . . .	(19)	Rear Sight.	(17)
Front Sight	(4)	Sear.	(39)
Hammer.	(38)	Slide	(94)
Lock Safety.	(45)		

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The five parts finished in the Pistol Department after being semi-finished elsewhere in the Company's plant, are listed below. The first number in parentheses indicates the number of operations performed in the Pistol Department, while the second number indicates operations performed in other departments:-

Extractor.	(27 and 2)	Grip Safety	(27 and 9)
Safety Lock Plunger. . .	(3 and 5)	Slide Stop Plunger. . .	(3 and 5)
Receiver.	(106 and 9)		

The six parts purchased from sub-contractors and finished in the Pistol Department, with departmental operations in parentheses, were:-

Barrel Bushing	(14)	Recoil Spring Plug. . .	(9)
Lanyard Loop	(3)	Slide Stop.	(26)
Recoil Spring Guide. . . .	(11)	Trigger	(7)

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

PRODUCTION INFORMATION - (Con't.)

The 32 finished parts which were purchased complete from sub-contractors for assembly into the completed Pistol were:-

Barrel - (issue free)	Lanyard Loop Pin	Magazine Pins
Barrel Link	Left Hand Stock	Magazine Tube
Barrel Link Pin	Right Hand Stock	Mainspring
Firing Pin	Magazine Base	Mainspring Cap
Firing Pin Spring	Magazine Catch	Plunger Spring
Hammer Pin	Magazine Catch Lock	Recoil Plate
Hammer Strut	Magazine Follower	Recoil Spring
Hammer Strut Pin	Mainspring Cap Pin	Sear Pin
Housing Pin Retainer	Stock Screw Bushing	Sear Spring
Magazine Catch Spring	Magazine Spring	Stock Screw
Magazine Housing Pin		Ejector Pin

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Some of the spare parts supplied by the Company were purchased from outside sources; others were made complete by the Company, while four parts were purchased semi-finished, and completed by the Company.

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Production, which at peak approximated 650 Pistols a day -- (plus spare parts) -- was achieved despite the series of delays and contingencies over which the Company had no control.

Difficulty in obtaining adequate stocks of annealed steel for a number of the parts was experienced at times. To keep production moving the Company was forced at times to anneal its own stock and, occasionally to re-anneal stock obtained from sub-contractors.

PRODUCTION INFORMATION - (Con't.)

Two of the parts produced by the Company gave considerable trouble during the early weeks of the contract. These pieces were the Slide and the Disconnector. The maximum tolerance allowed in the diameter of the drilled barrel hole on the Slide was .002". This was a special problem because the steel was hard to machine. This piece had a total of 94 operations in all performed on it. Manufacture of the Disconnector -- (which prevents the Pistol from being fully automatic) -- suffered because of inadequate gaging procedure. Inspection requirements on this piece later were changed by the Ordnance Department.

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Of the approximately 1,100 workers employed in production of the Pistol, about 1,000 were women who had had no previous factory experience. Lack of an adequate number of competent supervisors proved to be another problem. The women, however, proved to be willing workers and quick to learn, and soon brought production up. Labor turnover averaged less than 1% a month in the Pistol Department. There was no fixed training schedule; each woman was instructed in her specific duties by her supervisor.

Men were used to set up the machines, as foremen and as heavy laborers. Men also performed all polishing operations, heavy machine work, final assembly and testing. Many of the women in the Department were recruited from training classes in Pittsburgh schools.

PRODUCTION INFORMATION - (Con't.)

Possibly because the .45 Caliber Automatic Pistol was a dramatic item of battle equipment, one which it was known would be used personally by our fighting men, and it was produced virtually in its entirety by the Company, the enthusiasm and incentive within the Department ranked very high. Almost every employe in the Department expressed regret when the contract was cancelled and the manufacturing space was turned over to production of parts for the .30 Caliber Carbine.

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While no new construction was necessary to house the special Department in which the Pistol was produced, some construction was necessitated in the rearrangement of existing space. Approximately two floors -- or some 77,000 square feet of floor area -- were allocated to production, while another space -- 60' x 100' -- was set aside for the heavy machining operations. Other departments in the plant did miscellaneous part-time operations, or manufactured rough parts for the Pistols, the machining on these being done in the Pistol Department. A new lighting system was installed and a special lunch room was built within the Department.

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One item of construction was that of a special firing range, the design of which later was adopted by various pistol manufacturing

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

PRODUCTION INFORMATION - (Con't.)

plants. On this range each of the 55,000 Pistols produced by the Company was test-fired 21 times. A special bullet-trap -- devised by the Company -- was duplicated by the Company for the Colt Company, the chief producer of the Pistol, for use on its own range.

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Not a single Pistol manufactured and assembled by the Company, ever was rejected by the resident Ordnance Department Inspector. Of the 55,000 Pistols fired by the Company's own inspectors before being passed on to the Government inspector, only two failed in one test. They were found to be "completely automatic" in action, firing seven shots with one pull of the trigger, instead of being "semi-automatic," firing one shot with each of seven trigger pulls.

- - -

Reports received by the Company indicated that the Pistols it produced consistently rated high in tests for "interchangeability of parts." This test was conducted once a month, the four producers of the Pistol being required to send six Pistols each to the key inspector of the Small Arms Pistol Industry Integrating Committee. The Pistols were taken apart, the parts scrambled, and the twenty-four Pistols then re-assembled.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

PRODUCTION INFORMATION - (Con't.)

The Ordnance Department also affirmed to the Company that the finish on the Pistols of its manufacture was the best of all the producers, and that the "action" of the Pistols rated special commendation.

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The Company, together with other producers of the Pistol, loaned or borrowed tools, gages, and materials almost daily in order to keep production flowing at all plants. In a period of less than a year, the Company made more than 300 such individual transactions.

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In addition the Company devised a system of forecasting production accurately, the system being adopted as standard in the industry. It has since been used by the Ordnance Department for anticipating deliveries of other equipment.

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UPPER PUSH ROD TUBE PACKING GLAND NUT

Used on Ford Airplane Engine
(Federal Screw Works Orders)

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Total of 795,732 Pieces Produced by Company on Two Sub-contracts -- Inability of Prime Contractor to Supply Necessary Steel Delayed Production on Several Occasions -- Work on Part was Exacting and Tolerances Close

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Between March 22, and December 24, 1943, The Union Switch & Signal Company produced and shipped a total of 795,732 pieces of an item used on airplane engines being manufactured by the Ford Motor Company. The part -- produced on orders placed by the Federal Screw Works, Chelsea, Mich., was known as the Upper Push Rod Tube Packing Gland Nut.

Made of 1 9/16" steel, furnished by the prime contractor, the piece was .578" in length. It carried an internal 1 3/8" - 20 NS thread. Great care had to be taken with the thread which had a "Go" pitch diameter of 1.343", and a "No Go" pitch diameter of 1.347". The radius at the bottom of a 15/16" diameter hole also was very critical.

Considerable difficulty in obtaining the necessary supplies of steel from which the piece was machined, was experienced by the prime contractor. This led to delay in production on occasions, and also to the closing out of the orders at figures less than originally called for in the contracts.

The Westinghouse Air Brake Company negotiated the contracts for production of the Ford engine nut, and at the same time this company secured contracts for the machining of a somewhat similar item for use on the Buick airplane engine. The orders for the Ford engine nut were transferred to The Union Switch & Signal Company.

The first order received by the Company was for 865,500 pieces. This was received on December 24, 1942. The first shipment on this order went forward March 22, 1943, the order being closed out in the amount of 60,061 pieces with a final shipment on April 27, 1943.

The second order for the Ford engine nut was received on January 14, 1943, while the third order -- made a part of the second order -- was received on July 22, 1943. The second order called for 1,000,000 pieces. Because of a lack of steel this was closed out in the amount of 433,142 pieces on July 13, 1943. When supplies of steel again were secured, the order was re-instated in the amount of 550,153 pieces. This later was reduced to 523,153 pieces, but finally was closed out in the amount of 302,529 pieces, the final shipment being made on December 24, 1943, a total of 19,550 pieces being shipped on that date.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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All pieces produced by the Company -- unless otherwise specified -- were machined and semi-finished, then were shipped to the prime contractor for final operations before being used on the motors.

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PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

C A S C A D E I N V E R T E R S

(For Aircraft)

Types MG-149F and MG-149H

--o--

Three Departments Utilized in Production of Item Vital to Operation of U. S. Army Air Forces' Planes -- First Inverter Ready For Shipment Nine Days Before Contract Was Received -- Production Increased from 1,000 to 1,750 a Month with No Recorded Instance of Failure of Any Company-made Item During Service

--o--

Between June 21, 1943, and July 17, 1945, The Union Switch & Signal Company produced and shipped to the United States Army Air Forces a total of 28,250 units of an item of equipment used on aircraft -- (principally bombing planes) -- known as a Cascade Inverter. Two types of the Inverter were made by the Company. Both had the same function -- that of providing power to operate remote indicating instruments, fluorescent lights, radio equipment and small induction motors aboard an airplane. The equipment operates on a direct current input of 24 volts, delivering alternating current power at 26 and 115 volts. Two Inverters are used on each plane, being alternated in use at 45-minute intervals.

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Although the first contracts called for production of Type MG-149F Inverter, it was in August, 1944, that the Company received orders to produce another type -- MG-149H, a little larger and heavier type -- incorporating some changes in design and parts.

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Negotiations leading up to the initial contract for 10,500 of the MG-149F Type Inverters began on September 18, 1942, with a visit to the Company's plant by representatives of the Army Air Forces, from Wright Field, Ohio. These representatives brought samples of the Inverter with them -- it being a development of the Holtzer-Cabot Electric Com-

pany, Boston, Mass. The samples were examined and quotations on production were made the same day. Several months passed before receipt of a formal contract. However, on receipt of a letter of intent, the Company began production, and the first Inverter was ready to be shipped to Wright Field for tests, nine days before the formal contract was received. The contract was received June 17, 1943, and the Inverter was forwarded for test on June 21. Additional contracts for 2,000, 3,000, 4,000 and another 4,000 Type MG-149F, together with contracts for 5,605 and 2,250 Type MG-149H Inverters were received up to November, 1944. Of the latter two contracts one was closed out at 4,750 units, the other being cancelled in entirety.

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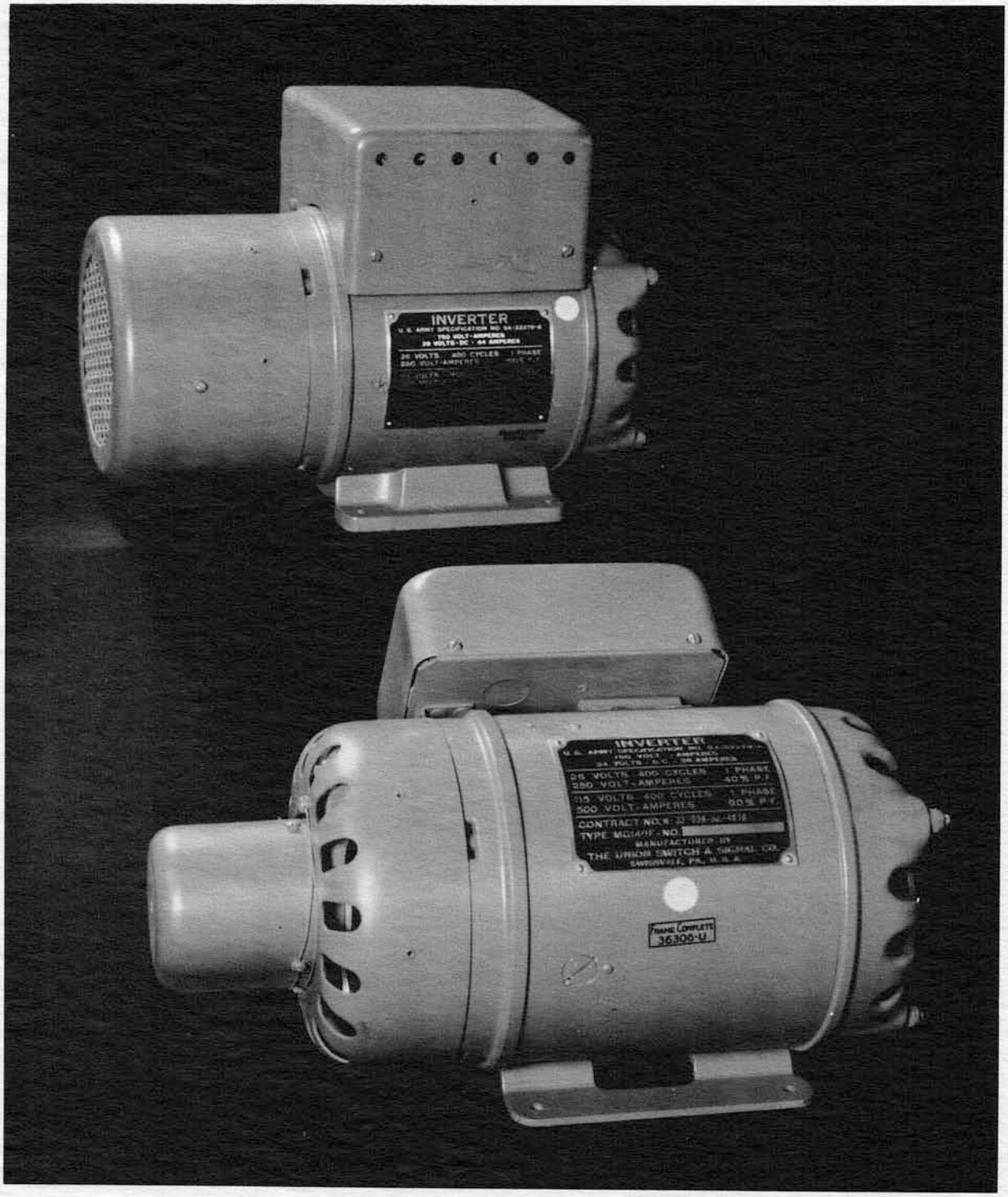
During the contracts production had increased from 1,000 a month to a peak of 1,750 and was being maintained at that rate until November, 1944, when the Company began to have difficulty in securing the necessary filter parts which were attached to the Inverter frames. Difficulty in securing supplies of ball-bearings had been encountered almost from the beginning of production so that contracts for spare parts -- in the amount of approximately 10% of the total number needed for the completely assembled units -- were cancelled.

* * *



CASCADE INVERTERS
(TOP) TYPE MG-149H (BOTTOM) TYPE MG-149F

DESCRIPTION OF THE INVERTER:

The Inverter consists of two units -- a motor, and a generator in a single frame. The motor is designed to operate at 6,000 rpm, and is provided with a governor to maintain this speed within the limits of 5,700 to 6,300 rpm from no load to a full load of 750-volt amperes, and over a primary d-c voltage range of 26.5- to 28.5-volts. The 750-volt ampere output is delivered at two voltages -- 26 and 115 volts. The 26-volt output is 250 volt amperes at 40% power factor, while the 115-volt output is 500-volt amperes at 90% power factor. The Inverter is capable of delivering this output continuously.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

This type of device is referred to as a "cascade" Inverter since the conversion from dc to ac is made in two stages. In the conductors between the d-c and the a-c ends of the armature there exists multi-phase 200-cycle current. Thus the dc is first converted -- by ordinary converter action -- to 200-cycles, and the energy then is stepped up to 400 cycles in the a-c end of the machine.

- - -

A filter -- which is mounted on the frame of the Inverter -- is provided for the purpose of reducing radio frequency interference, and a two-position switch is provided to permit operation of the Inverter with one-half rated load on the 115-volt circuit. With the switch in the "LO" position, approximately 115 volts is obtained at one-half rated load.

* * *

HISTORY OF THE CONTRACTS:

First Contract. As stated previously the Company was first approached to produce the MG-149F Type Inverter on September 18, 1942, by representatives from the Army Air Forces at Wright Field, Ohio.

Samples of the Inverter were examined and quotations for production were made. This called for the machining of certain parts; the assembly and machining of others; winding of armatures; purchase of certain parts and their assembly into the Inverter unit; testing, painting and shipment. In addition the Company was to manufacture -- or otherwise supply -- replacement parts for the Inverters in the number of approximately 10% of the total number of units supplied.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Within a week the Company sent its representatives to the plant of the Holtzer-Cabot Electric Company, Boston, Mass., then the sole producer of the Inverter, to study methods of manufacture, assembly, inspection and test, and the various techniques employed, and also to secure data on the equipment, tools, jigs, fixtures, etc., needed. Upon their return these representatives began setting up for production and training crews for a production line. With the exception of certain stamping and machining operations, these crews were composed solely of women.

A letter of intent for 10,500 Inverters was received by the Company and production was started, the first Inverter being ready for

CONTRACT HISTORY - (Con't.)

shipment on June 8, 1943. The formal contract was received on June 17, and the first Inverter was sent to Wright Field for testing -- both operational and for interchangeability of parts with Inverters manufactured by Holtzer-Cabot. This was on June 21. On June 30 another 15 Inverters were forwarded. On July 7 the Company was advised that the first Inverter had successfully passed all tests to which it had as yet been subjected.

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During July another 64 Inverters were shipped, followed by 600 in August; 800 in September, and then -- from October 1, 1943, through June 30, 1944 -- they went forward at the rate of 1,000 a month.

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The original schedule of shipments set up when the contract was awarded was revised from time to time to meet Army Air Forces requirements, so that the first contract was completed on schedule. Shipment of the spare -- or replacement -- parts also was on schedule. There were 34 different parts which were furnished in amounts varying from 5 to 1,200 of each, for each 100 Inverters shipped.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

Second Contract. Even before production on the first contract was well under way, the Company received an inquiry for production of an additional 2,000 Inverters. This was on July 29, 1943. Quotations were made on August 9, and a purchase order was received October 20. Included also was an order for replacement parts -- as was the case under the first contract.

The schedule set up called for 1,000 Inverters to be delivered during July, 1944, and the same number during August. This schedule later was changed to 1,250 in July and 750 in August. The first shipment -- of 200 Inverters -- was made July 6, 1944, a total of 1,100 going forward that month. The last shipment, completing the contract, was made August 25.

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Third Contract. Inquiry and quotations on this order were made on February 14, 1944, the purchase order -- in the amount of 3,000 Inverters -- being received on February 21. Shipment of 1,000 a month during September, October and November, was called for. This schedule was changed several times before any shipments were made but 350 had gone forward before the end of August, and the contract was completed with a final shipment on October 30.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

Fourth Contract. On June 6, 1944 -- the month during which the final shipment of Inverters on the First Order was made -- the Company received an inquiry for production of another 4,000 units. Quotations went forward June 16 and 20, the purchase order being received on August 3. Shipments were to begin on October, 1944, and conclude in February, 1945. The schedule was revised several times until -- on September 9, 1944 -- it called for 100 Inverters in October, 1,750 each in November and December, and 400 in January, 1945. The first shipment was made in October, while the last went forward on March 3, 1945.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Considerable difficulty was experienced on this contract in securing the necessary filters so as to keep shipments up to schedule. On January 20, 1945, a total of 2,766 Inverters was being held in the Company's Bond Room, waiting for filters so that final testing could be made before shipment.

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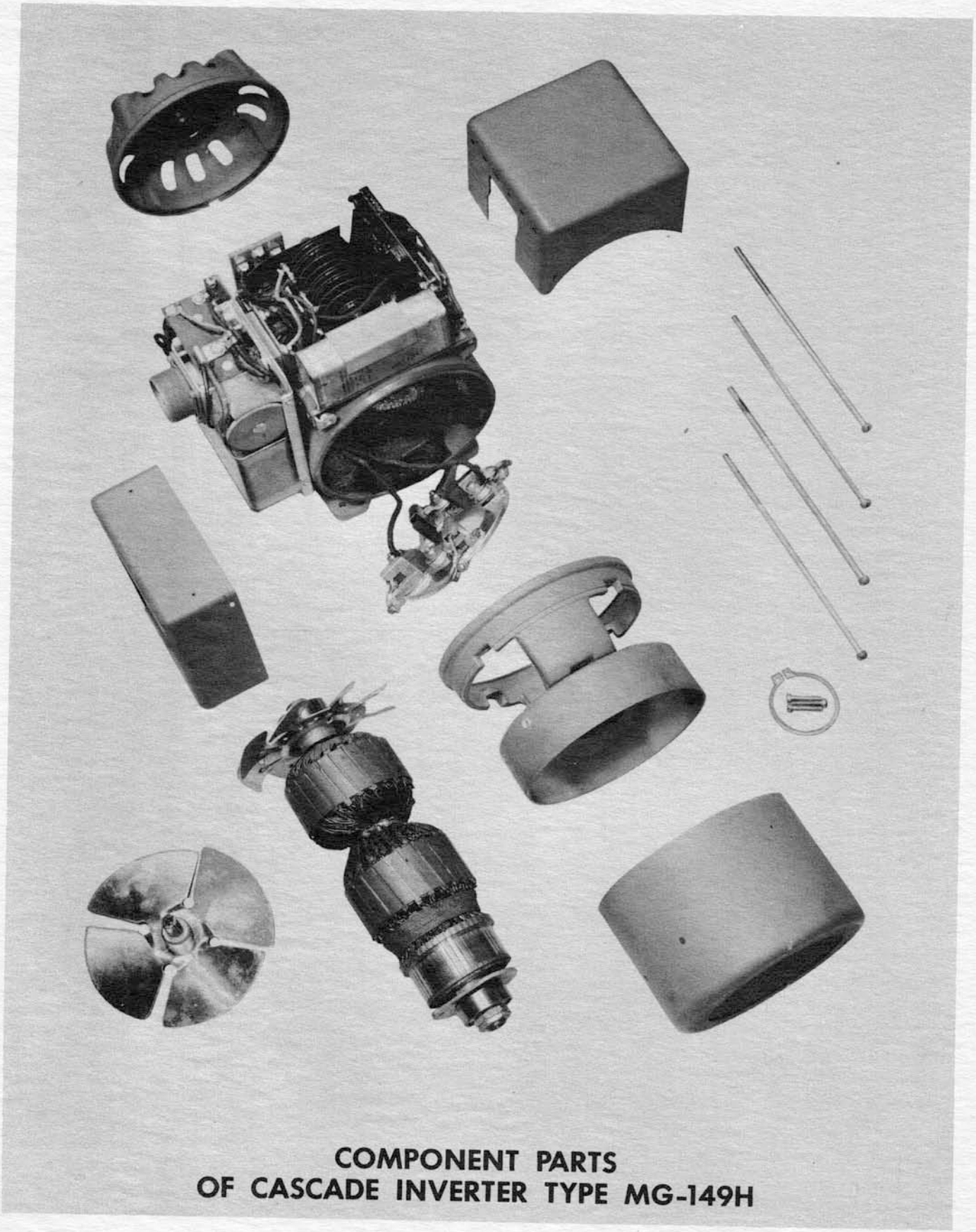
Fifth Contract. During July, 1944, the Company was advised that certain modifications had been made in the Inverter design by the Air Forces engineers and the Holtzer-Cabot Company, and that a new type Inverter -- larger, heavier and with several new parts -- soon would be produced. Among the changes was the elimination of the Governor, substitution of a new type of case base, and addition of a pusher fan for cooling a new type of speed control. A snap ring also was added on the



COMPONENT PARTS
OF CASCADE INVERTER TYPE MG-149H

CONTRACT HISTORY - (Con't.)

outside of the front bearing hub for the purpose of keeping three bearing screws from loosening. It was during the Fourth Contract that the Company was advised of the new type Inverter, the order -- originally for the "F" type, being changed to the "H" type and then back to the "F" type again. The Fifth Contract was -- therefore -- the first order for the new type Inverter.

On August 7, the Company received inquiries regarding production of a total of 9,605 Inverters. Of this number, 4,000 were to be of the "F" type, and 5,605 of the new, or "H" type. The quotation was made on August 10, the Company receiving notice of the award on August 25. Shipments -- of the "F" type Inverter were to start in January, 1945 and run through March, while shipment of the "H" type was to start in March, 1945 and run through June.

On May 2, 1945, the quantity of the "H" Type Inverter ordered was cut back to 4,750, the contract being closed out at that figure.

The first shipment of the "F" Type Inverter was made in March, 1945, the last on May 10. The first shipment of the "H" type likewise was made in March, the last shipment going forward on July 17, 1945.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

Sixth Contract. This order for 2,250 "H" type Inverters, was received on November 13, 1944, following inquiries on October 24, and quotations made October 31. Deliveries were to be made 500 in June, and 1,750 in July, 1945. However the contract was cancelled in entirety on May 2, 1945, the same date the order for 5,605 "H" type Inverters contained in the Fourth Order, was cut back to 4,750.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

In October, 1944, the Company was advised that a certain number of the "F" type Inverters were to be packed in steel containers, or cans, for export shipment. This called for some revision of the cost estimates and quotations and these were made early in 1945. The 4,750 "H" type Inverters called for in the Fourth Order, were to be export-packed.

* * *

MANUFACTURING OPERATIONS:

The combined efforts of several departments went into the manufacture of the Cascade Inverter. The Company for years has wound armatures in connection with its manufacture of its regular line of various signaling devices and controls, and this experience was made use

MANUFACTURING OPERATIONS - (Con't.)

of in that parts for the Inverters could be made quickly and be ready for speedy assembly. Approximately 1,200 square feet of floor space was set aside for a special department in which the armatures and the stators used in the Inverter were wound. The following six operations were performed in this department, use being made of jigs and fixtures devised or developed by the Company:-

Wind d-c end and assemble commutator; connect d-c end to commutator; wind a-c end; connect a-c end to commutator; solder leads to commutator; varnish. Ground testing and other tests were made after each operation.

The field coils likewise were wound and fully tested by the Company in this same department.

The armatures were sent to one of the Grinding Departments where the a-c and d-c ends were ground and inspected, after which they were taken to a Lathe Department where the end of the armature shaft that holds the rotating governor was bored. The units then were returned to the armature winding department where the commutator was turned and undercut, after which the armatures were given final electrical and mechanical inspection.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

In the assembly of the Inverters, the following operations were performed:-

(1) Attach fan to armature assembly, balance armature, pressing bearing on shaft. (2) Assembly of Field Ring: position four d-c pole pieces, pressing a-c stator into shell, screw d-c field coils into shell and inspect; (3) insert pin and expanding ring in front cap.

(4) Final Assembly: place brush ring assembly in front cap, press front cap on d-c end of field ring assembly, press back cap on a-c end of field ring assembly, fastening front and back caps with four tie bolts; position rotating member of governor and stationary parts, then attach radio filter and connect wiring, attaching brushes; (5) final plant mechanical inspection.

(6) Electrical Inspection: setting brushes, adjust governor for speed, conduct eight-hour running test; (7) final paint field ring; (8) final electrical test of 15 minutes at resistive load to heat motor, keeping a record of performance under various loads; (9) seal and pack.

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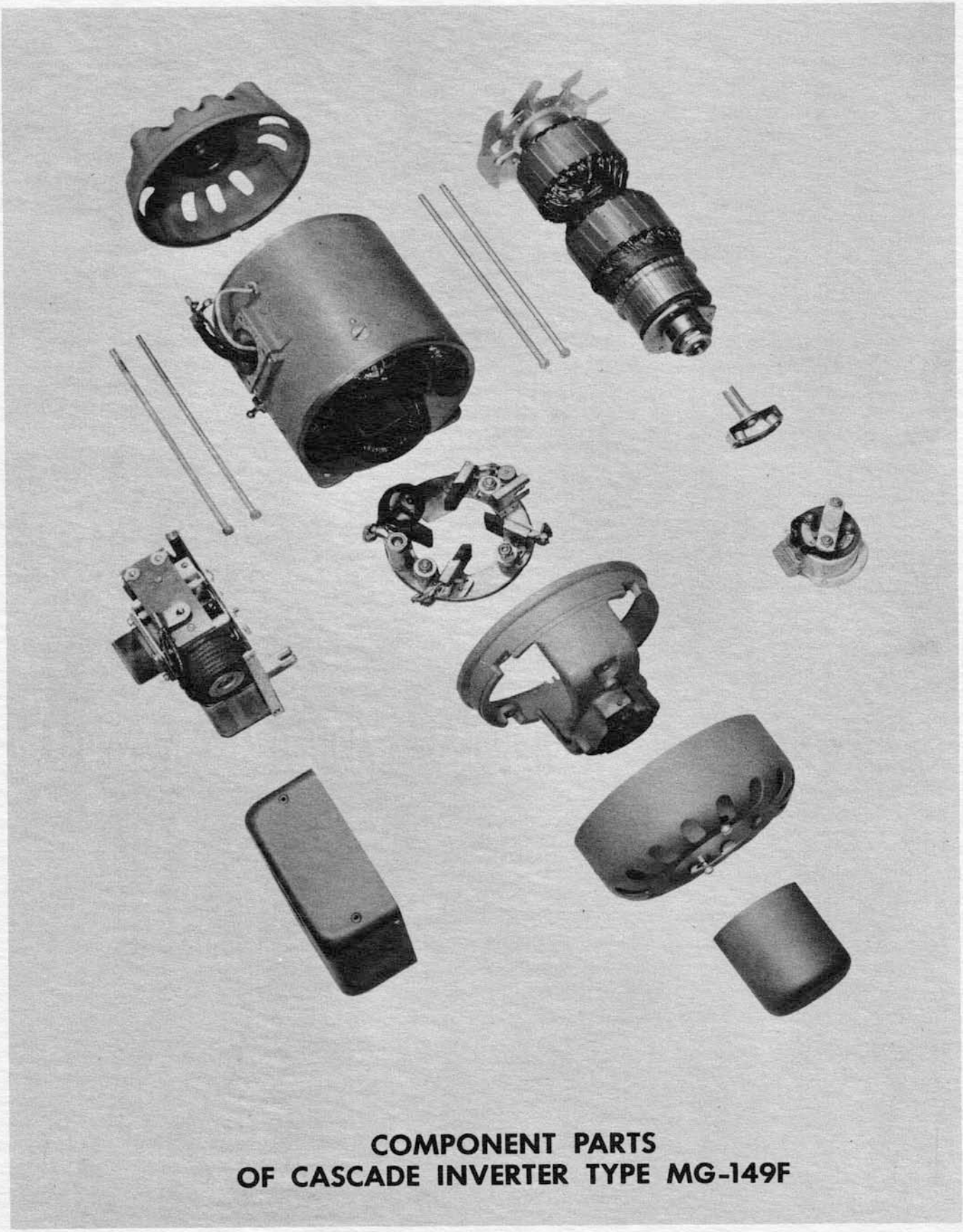
PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY



COMPONENT PARTS
OF CASCADE INVERTER TYPE MG-149F

MANUFACTURING DIFFICULTIES:

Early difficulties in production were quickly overcome when the new employes became trained in their work, with the result that the assembly of the Inverters proceeded at an accelerated pace.

One of the earliest "bugs" in Inverter production, however, developed in the machining of the Field Ring -- (the metal shell in/on which the various parts of the Inverter are placed or attached). One of the Air Forces requirements was that the complete Inverter -- of the MG-149F Type -- should weigh no more than twenty-and-one-half pounds, fully assembled. This necessitated a very thin steel tubing for the Field Ring. Because it was thin it had a tendency to be springy and to get out-of-round. Although this in no way interfered with the performance of the Inverter, nor with the interchangeability of parts, the test for shape of this ring was one that constituted the most serious cause for rejection under the rigid inspection of the Air Forces.

Use of a stationary cutting tool, with the work moving at a predetermined speed, overcame the trouble with the ring to a large degree, the centrifugal force exerted on the turning tubing having a tendency to keep it in shape.

Difficulty in obtaining dies to cut the laminations on the armatures and the stators also was encountered at first. Then -- in order to conserve metal -- the armature disc was cut from the center of the stator lamination. Annealing difficulties were overcome when a cylin-

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING DIFFICULTIES - (Con't.)

der was devised to replace box-type holders used to hold laminations in the furnace, when the box-type holders proved unsatisfactory. A multiple assembly fixture for the d-c pole piece laminations also was developed by the Company.

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In order to reduce weight, the shafts used had to be made of tubing. This had to be turned and ground to .001" maximum allowance on three diameters, and .002" allowance on two other diameters. In the boring of the bearing holes in the end caps -- which were made from magnesium castings -- a total tolerance of .0002" was allowed. These various requirements presented difficulties during the early days of production were -- in a large measure -- overcome by the Company before termination of contracts.

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An ingenious idea worked out by the Company was the substitution of a frequency meter for a tachometer to determine the speed of the Inverter, and to regulate it -- by means of a 3-position switch -- to 6,000 rpm. When the Inverter was first produced, it required several tries with a tachometer before the speed could be determined. By means of the frequency meter the amount of current used was measured in microamperage. When the switch was on "Low", the speed was approximately

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

BALANCING CASCADE INVERTER ARMATURE ON DYNAMIC BALANCING MACHINE

MANUFACTURING DIFFICULTIES - (Con't.)

5,975 rpm; when on "Medium" the speed was approximately 6,000 rpm, and when on "High" the speed was approximately 6,025 rpm. Movement of the needle on the meter at each of the three positions of the switch, revealed the rpm, and the governor was adjusted so that between 6,000 and 6,025 rpm was recorded, the tolerance being between 5,975 and 6,025 rpm with preference being given to the rpm on the high side.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

A dynamic balancing machine, making use of a stroboscopic lamp, also was employed by the Company to balance the armature. If unequal balance at either end of the armature was noted, weights were pressed on the shaft to correct the unequality, before the armature was assembled into the field ring.

* * *

GENERAL REMARKS:

No new building construction was necessitated for production of the Inverters. Use was made of existing space, some 3,400 square feet being assigned to the various assembly lines, in addition to space set aside in other departments to handle various items connected with the work on the item.

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GENERAL REMARKS - (Con't.)

In addition to the dynamic balancing machine, certain other testing equipment and special meters had to be purchased by the Company, but much machinery already on hand was converted for use in production of the Inverter. The Company also designed and made many of the special tools, fixtures and jigs in its own tool rooms -- most of them in record time.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

As stated previously most of the production workers were women. The armature winding department, consisting of from 25 to 30 women, worked two shifts, six days a week. The grinding and lathe work was done by men, some operations covering two shifts, seven days a week. An additional 20 women, and about five men, composed the final assembly department, this department working a single shift, six days a week. Virtually all the inspection and testing was done by women. The employment of women -- some few of whom had had previous factory experience, and some few of whom had taken the special defense training courses conducted in the Pittsburgh schools -- met with marked success.

Because of the nature of the work, it was the policy of the Company to employ -- as far as possible -- only women whose immediate male relatives were serving in the armed forces.

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GENERAL REMARKS - (Con't.)

So far as is known there never was a reported failure in action of any Inverter produced by the Company. Every production schedule over which the Company had any control was met, while rejections during plant inspection were held to approximately 1% or less.

The inspections conducted by the Company were rigorous, while three inspectors from the Army Air Forces, stationed at the plant during the entire time of production of the Inverters, also were most exacting in their work.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

IGNITION SHIELD ASSEMBLIES

(For Army Air Force)
(and)
(Ford Motor Company)

(Titeflex Metal Hose Co., Contracts)

--o--

Company Met with Outstanding Success in Training Women to Perform Complicated Job of Assembly and Wiring -- Peak Production Reached Within Few Months -- Lack of Supplies Prevented Completion of Contracts on Schedule -- Many Parts for Item Produced by Company

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As a sub-contractor to the Titeflex Metal Hose Company, Newark, N. J., The Union Switch & Signal Company -- during the period between May, 1943, and June, 1944 -- assembled and shipped a total of 17,210 sets of an item known as an Ignition Shield Harness. These were used on airplanes equipped with Pratt & Whitney motors to eliminate motor ignition noises from the plane's radios. One complete unit was attached to each motor with which the plane was powered.

Two types of the Harness were produced by the Company -- one to the specifications of the Army Air Forces, the other to those of the Ford Motor Company. In addition, a number of parts, such as screws, nuts, spacers, washers, gaskets, copper ferrules, etc., were supplied to the Titeflex Company, as well as a total of 2,920 castings for the distributor body.

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Every schedule over which the Company had any control was met, the only delays being occasioned by failure of the Titeflex Company, or the Ford Motor Company, to furnish those parts of the Harness not manufactured by the Company.

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Because it was known that the Company had broad experience in the manufacture of various wired electrical devices, the Army Air Forces, early in 1942, approached the Company with a view to having it tool up to produce the radio shield assemblies. In fact a contract calling for 70,000 such assemblies, was drawn up but later was cancelled. This prime contract later was transferred to the Titeflex Metal Hose Company for which company The Union Switch & Signal Company became a dominant producer under sub-contracts, the first for 10,000 assemblies.

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DESCRIPTION OF HARNESS:

Consisting of a right-hand, a left-hand, and a center section of brass tubing, which were affixed to two magnesium distributor bodies, the complete unit somewhat resembled a horse collar. Within the sections of tubing ran 36 wires -- each of a predetermined length -- which in turn branched out from the tubing through cables. At one end of each wire there was affixed a spark plug connector, each connector being attached to a plug on the 18-cylinder motor. The other end of each wire entered the distributor housing.

* * *

CONTRACT HISTORY:

As stated previously the Titeflex Company sub-contracted the assembly of 10,000 harnesses for the Army Air Forces, to The Union Switch & Signal Company. It was early in October, 1942, that the Company was asked if it would undertake the work. Quotations were made October 27, and the order was received November 9. The schedule called for first shipments to be made in May, 1943, with the order to be completed by February, 1944.

> Failure to receive necessary supplies, together with a constant change in the specifications, held up production, but the first shipment -- of five sets -- went forward on May 12, 1943. The last shipment was made under this order on June 2, 1944, in the amount of 200 sets. In connection with the changes in specifications these were received in such rapid sequence that often while material was being changed in accordance with a newly received change order, a new change order would be received, and work would have to be done over.

- - -

Before production had commenced on the order for the Air Forces harnesses, the Company was asked to make harnesses in accordance with specifications of the Ford Motor Company. This was on March 8, 1943. The initial order was for 9,600 sets,

CONTRACT HISTORY - (Con't.)

with shipments to start in May. On April 16, however, the order was cut back to 8,100 sets. Then on April 26, ten days later, another cut-back -- to 5,810 sets -- was received. A new schedule was set up calling for first shipments in August, and the last in December, with a peak shipment -- of 1,650 sets -- to be made in November. Actual shipments began with 150 sets on July 30, 1943, and the order was finished with a shipment of 100 sets on April 13, 1944.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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On October 22, 1943, another order for 2,200 additional sets of Harness to be built to the Ford specifications, was received from the Titeflex Company. This called for 775 sets in March, and 1,425 sets in April, 1944. Due to a cancellation of contract, however, the order was cut back 800 pieces, to a total of 1,400, on March 17, 1944. The first 100 sets were shipped on April 13, and the final 163 sets on June 24, 1944.

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Other orders from the Titeflex Company, which the Company filled, included one for 50 each of the right half, left half, and center segment manifold

CONTRACT HISTORY - (Con't.)

assembly. These were ordered February 16, 1943, and filled complete on March 1. Also: -- 2,000 distributor body castings, and an additional 720 of the same piece, both ordered on April 15, 1943, were delivered between May 13, 1943, and March 4, 1944. An additional 200 such castings were ordered July 24, 1943. The deliveries on this order were made between April 24, and May 1, 1944.

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Other items ordered -- in addition to body castings, screws, buts, washers, etc. -- were 4,000 high tension wire assemblies. These were ordered between May 21, and June 2, 1943, and were delivered between May 22, and September 2, 1943. A total of 10,000 radio shield ignition manifolds -- to be delivered to the Ford Motor Company -- was ordered on March 3, 1944. This, subsequently, was whittled down to a total of 1,733 pieces, which were delivered between July 5, and September 30, 1944.

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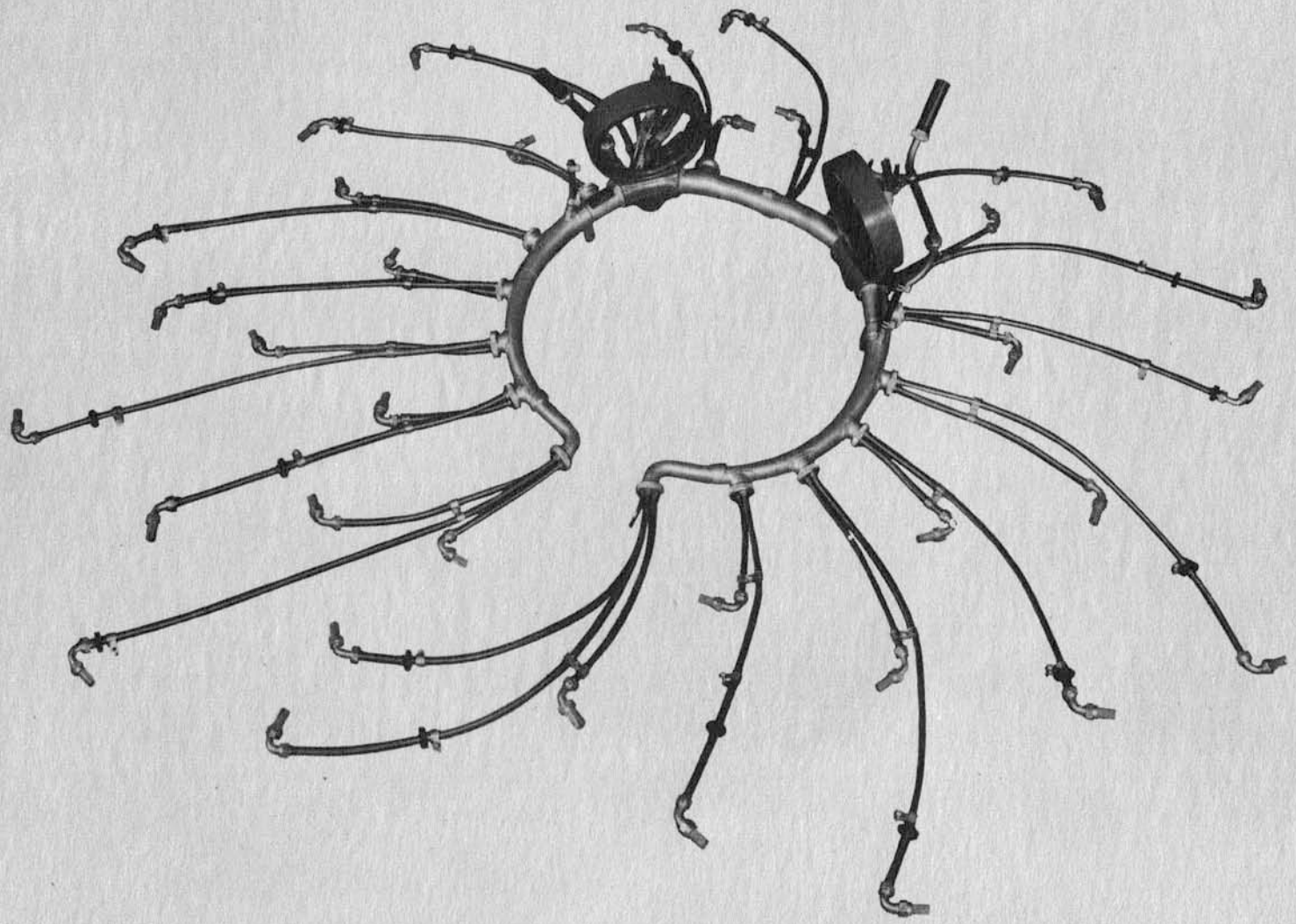
PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY



IGNITION SHIELD HARNESS ASSEMBLY
FOR ARMY AIRPLANE MOTORS

GENERAL REMARKS:

When inquiries were made of the Company as to whether it would take on production of the Ignition Shield Harness, several representatives of the Company were sent to the plant of the Titeflex Company, there to study manufacturing methods and techniques, and to ascertain what tools, machines and equipment were needed. Such special tools as were required were furnished from outside the Company. Some existing machinery in the plant was made use of, while some new items were acquired. The magnesium housings for the distributors were machined by the Company or -- in the case of those used on the harnesses built to Ford specifications -- were furnished by the Ford Motor Company. Some of the other items used in the assembly were made by the Company. These included screws, nuts, washers, etc., but most of the approximately 250 parts were supplied by the Titeflex Company.

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Upon their return, Company representatives began training crews of women to perform the various operations. During peak production approximately 250 women were employed, about 10% of whom were assigned to the various rigid inspections. Very few of the women had had any previous factory experience. Insofar as possible the Company gave employment preference to those women having members of their immediate families in the services.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - (Con't.)

After production got under way and the various crews gained experience, the percentage of rejections began to lessen. Within a short time it was well within the "scrap" allowance. One of the leading causes for rejection was in the soldering, there being pin-hole "leaks" where the brackets were silver-soldered to the tubing. This difficulty was largely overcome by making the soldering one of the final, instead of one of the first, operations. The brackets were used to attach the equipment to the motor of the airplane and while the pin-holes had no effect on the performance or life of the equipment, nevertheless their presence constituted cause for rejection.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

* * *

MANUFACTURING OPERATIONS:

The right-hand and the left-hand sections of the brass tubing from which the harness was built up, were subject to the same fabricating processes. These were:-

(1) Cut tubing to length on band saw; (2) weld two brackets and an elbow to tubing; (3) scribe five outlets on tubing and cut holes with band-saw; (4) drill air inlet hole, and burr; (5) radius air inlet hole by hand; (6) rough cut, undercut and buff five outlet holes.

After cleaning at this point, the operations continued;- (7) swage and solder inside elbow; (8) Kellerflex grind inside elbow; (9) inspect soldered joint; (10) assemble and silver-solder drain outlet (for condensate that might collect); (11) fit five outlet

MANUFACTURING OPERATIONS - (Con't.)

connections on tubing, tack in place for welding; (12) shape, and remove sharp edges from inside of five outlet connections; (13) inspect edges; (14) weld five outlet connections; (15) cut tubing to length and radius on drill press; (16) burr and sand ends; (17) grind and buff outlets, ferrules and brackets, and silver-solder brackets and elbows in place.

Then -- after the section was pickled and baked -- the operations proceeded:- (18) adjust shape of tubing and outlets on jig; (19) stencil; (20) run die over threads on outlet fittings, check with gage and inspect threads; (21) braze defects and remove sharp edges from outlets and brackets, and remove dents from tubing; (22) inspect; (23) buff radius on large brackets, final buff both large and small brackets; hand file burr under large bracket.

The piece then was cadmium plated, baked for three hours at 270°, brushed with oil and these final operations were performed:- (24) inspect threads with gage; (25) align tubing and outlets on jig; (26) final inspection.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Fabrication of the smaller center section of tubing was much the same as for the two other sections. There were only three outlet holes with fittings, and one mounting bracket.

Then followed the assembly of the right- and left-hand sections and the center section, the three being joined by means of two magnesium castings that housed the distributors. Here there was noted one difference between the harnesses for the Army Air Forces and those for the Ford Motor Company. The Company machined the housings for the former orders, while it only assembled the housings to the shield for the Ford Motor Company which supplied the housings already machined. These latter bore the name "Ford."

MANUFACTURING OPERATIONS - (Con't.)

Another difference between the two was that a 5 mm. Neoprene wiring -- built up to 7 mm. by means of a sleeve -- was specified for the Army Air Forces harness, together with steel fittings -- (made by the Company and having to pass a 16-point inspection) -- while 7 mm. wire with latex rubber, and lacquer covered wood or glass fittings were called for by the Ford specifications.

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The assembly of the wires in the brass tubing -- (there were 36 separate wires in each assembly) -- was a painstaking process, and ran as follows:-

(1) Cut 36 individual wires, each to specified length; (2) assemble spark plug connector to end of each wire, by inserting elbow and cap and cutting and flairing wires to connector; (3) assembling conduit over wires; (4) inserting conduits in tubing; (5) inserting brass reducing bushing -- (made by the Company) -- in each magnesium housing and wiring it tight; (6) inspect wire conduits and elbows on jig table; each conduit for specified length and each elbow for angel; (7) cut wires leading to distributor inside magnesium housing to within 1/16" of specified length; (8) crimp furls on each of the 36 wires; (9) electrically test at 9,000 volts for 15 seconds; (10) inspect -- (this called not only for visual inspection but also a check-light test of each individual wire to determine if each was in specified

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS - (Con't.)

sequence, and if each was properly identified; (11) attach kit of screws, nuts, bolts, etc., used to anchor the Assembly to the airplane motor's ignition; (12) Army Air Forces inspection; (13) pack for shipment, one assembly to a carton.

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Despite the many requirements, both in assembly and inspection, production increased so that at peak approximately 100 units a day were being turned out.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

UNITED STATES CARBINE - Caliber .30 M1

(Bolts, Slides and Receivers)

--o--

Three Prime Contractors Supplied with Total of 323,352 Parts in Seven Months -- Extra Forgings Also Supplied -- Mandatory Changes in Design, Plus Delays in Procurement of Machines, Tools, Fixtures and Gages, Contributed to Slowing Production -- Company Told It Did "A Good Job" Under Adverse Conditions

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Early in 1943 The Union Switch & Signal Company was asked to take on production of three essential parts for the new .30 Caliber Carbine, a short, light rifle used extensively by paratroopers, machine gunners, the Seabees and other units. This rifle then was in process of being developed by the United States on the basis of reports of its performance under actual battle conditions.

The Company sub-contracted for the production of the three parts -- the Bolt, the Slide and the Receiver -- to three prime contractors. These were The National Postal Meter Company, Rochester, N. Y., the Quality Hardware & Machine Corporation, and the Rock-Ola Corporation, the latter two both of Chicago, Illinois.

Although -- due to a variety of circumstances, described later in this report -- the Company did not succeed in making the first delivery of any of the three parts until August 1, 1943, it did produce and ship a total of 323,352 pieces to the three prime contractors. In addition, two of the prime contractors were supplied with forgings for the Bolt and the Slide in the amount of 228,653 pieces, and also machined 6,000 Bolts for yet another contractor -- International Business Machines Corporation.

Only a change in the Government procurement program resulted in cancellation of the major contracts.

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At the time of the cancellation the Company was advised -- both by representatives of the Government, as well as by two of the prime contractors -- that it had "done a good job" of production, considering the delays in receiving equipment. An Ordnance Department representative stated that the Company "--had done at least as anyone else had in the time of getting started, and that the original scheduled demands were absolutely impossible of meeting under any circumstances."

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

HISTORY OF THE CONTRACTS:

At a meeting held at the offices of the Company in Swissvale, Pa., on February 10, 1943, with representatives of the Ordnance Department, the Rochester (N. Y.), and Chicago (Ill.) Ordnance Districts, and of the three prime contractors, the Company was asked to undertake the manufacture of Bolts, Slides and Receivers for the U. S. Carbine, Caliber .30 M1. Machinery and tools already located in the Company's plant, and used in production of the .45 Caliber Automatic Pistol -- (see Pages 176-191 of this report) -- were to be used insofar as possible in the manufacture of the Carbine parts. The Government was to furnish additional machines, tools, fixtures and gages, while the tooling up was to be done by the Quality Hardware & Machine Corp., one of the prime contractors attending the meeting. This corporation also was to furnish special tools needed in production of the Carbine parts.

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CONTRACT HISTORY - (Con't.)

Production schedules were discussed at this preliminary meeting but no commitments were made. However -- since delivery of the Carbines was desired in June, 1943 -- it was stressed that the Company should begin delivery of the Carbine parts in May.

Quotations on the work of production were made at this meeting, and the next day -- February 11, 1943 -- the contracts were awarded to the Company.

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In the table below is shown the numbers of each part contracted for, together with actual deliveries of each part, and the dates through which the parts were shipped:-

	Part and Amounts			
Contractor	Slides	Bolts	Receivers	Totals:
Nat. Post. Met. Co.	97,200	100,800	90,000	288,000
Dels: 8/43 to 3/44	64,602	54,593	50,052	169,247
Qual. Hdw. & Mach.	116,640	120,960	108,000	345,600
Dels: 8/43 to 3/44	65,246	55,482	28,949	149,677
Rock-Ola Corp.	116,640	120,960	108,000	345,600
Dels: 8/43 to 10/43	1,150	3,278	- o -	4,428
Totals Ordered:	330,480	342,720	306,000	979,200
Total Deliveries:	130,998	113,353	79,001	323,352

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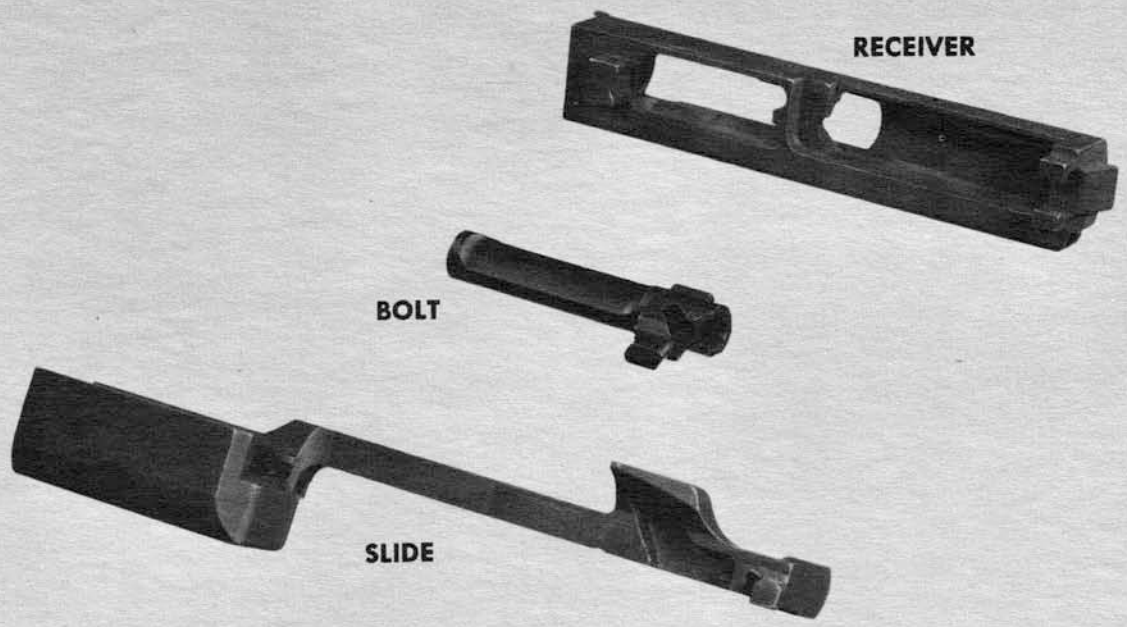
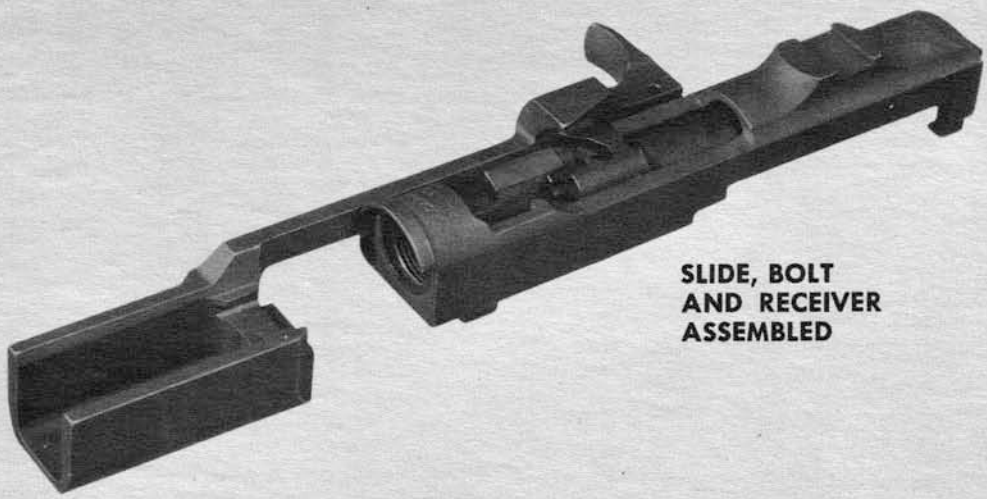
PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY





PARTS FOR U. S. CARBINE, CALIBER .30M1

CONTRACT HISTORY - (Con't.)

Although no shipping schedule had been set up -- either during negotiations or at the time of the award of the contracts -- a short time after the contracts were received, the War Department set up a schedule arbitrarily calling for delivery of each of the parts to begin in June, in the following amounts, and to be carried on until completion of each contract:-

To the National Postal Meter Company

Slides -- 16,200 Bolts -- 16,800 Receivers -- 15,000

In proportionate amounts to the other contractors

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Then -- in May -- the National Postal Meter Company asked The Union Switch & Signal Company to set up a realistic schedule of deliveries, with pilot parts to be shipped in June. This schedule was devised, to serve as a basis for delivery to the other contractors, as well:-

Month	Slide	Bolt	Receiver	
July	3,240	3,360	3,000	
August	8,100	8,400	7,500	
September	12,150	12,600	11,250	
Oct., Nov., Dec., Jan.	16,200	16,800	15,000	(In each of these months
February	8,910	9,240	8,250	
Totals:	97,200	100,800	90,000	

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

Then, on August 2, 1943, the Company and the prime contractors were advised by the Office, Chief of Ordnance, that the Government's expansion program would cease -- as of December 31, 1943 -- consequently there would be some cuts in production, so that delivery schedules would have to be revised during August, to the following:-

2,000, 4,000, and 8,000 of each part to each contractor during the months of August, September and October, respectively. The shipments were to be increased during November -- to continue in the following amounts -- until completion of the contracts:-

Contractor	Slides	Bolts	Receivers
Nat. Post. Met. Co.	16,640	17,360	15,200
Qual. Hdw. & Mach.	20,528	21,392	18,800
Rock-Ola Corp.	20,528	21,392	18,800

- - -

There had been considerable difficulty in procuring machines, fixtures, tools and gages up to this time, and the Company was just getting production under way. First shipments of parts to all prime contractors was made August 31, 1943, in the following amounts:-

National Postal Meter Company, 200 Bolts and 700 Slides; Quality Hardware & Machine Corp., and Rock-Ola Corp., each 150 Bolts and 150 Slides.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

Further shipments of Bolts and Slides were being made to all prime contractors when -- on October 26, 1943 -- the Rock-Ola Corporation notified the Company that since it had not shipped any Receivers, as called for under the contract, the latter was being cancelled as of that date. The Company had made a shipment of 300 Slides, for a total of 1,150 to the Rock-Ola Corp., on August 21, and on October 28, a shipment of 300 Bolts was made, for a total of 3,278 in all.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The first shipment of Receivers to the National Postal Meter Company was made in the amount of 12 pieces on October 28, while a "clean-up" shipment of 68 Receivers was made on May 23, 1944, for a total of 50,052 in all.

A total of 38 Receivers was shipped to Quality Hardware & Machine Corp., on October 29, 1943, as the first shipment of that part to that Company. The final shipment of Receivers went forward in March, 1944, for a total of 28,949 in all.

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Finally -- on December 29, 1943, Army and Ordnance Department officers, together with representatives of the two remaining prime contractors met at the Company's offices. It was stated by the Government representatives that -- due to a major change in the Government's program, necessitating a change in the procurement program -- existing

CONTRACT HISTORY - (Con't.)

contracts for Carbine Parts were to be cancelled. The Company was told at this time that it had done "a good job" in production, and the further statement was made -- as previously reported -- that "--- the original scheduled demands were absolutely impossible of meeting under any circumstances."

While at this meeting Quality Hardware & Machine Corp., cancelled its contract as of January 1, 1944, it agreed to accept such work as was then in process. The National Postal Meter Company said it would accept shipments up to March 31, 1944, when its contract would be cancelled.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The final shipments were made as follows:-

Quality Hardware & Machine Corporation

700 Bolts on February 5, 1944, for a total of. 55,482
225 Slides on February 17, 1944, for a total of. . . . 65,246
500 Receivers on March 15, 1944, for a total of. . . . 28,949

National Postal Meter Company

2,000 Bolts on February 4, 1944, for a total of. . . . 54,593
334 Slides on February 19, 1944, for a total of. . . . 64,602
1,400 Receivers on March 17, 1944, for a total of. . 50,052 (*)

(*) Includes 68 Receivers shipped on a "clean-up" on May 23, 1944. These were replacement pieces.

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CONTRACT HISTORY - (Con't.)

During February, 1944 -- in addition to the foregoing contracts -- the Company also machined 6,000 Bolts for International Business Machines Corporation. The first contract -- calling for 5,200 Bolts -- was awarded February 9, 1944. On February 24 a second contract, calling for an additional 800 Bolts, was received. All were shipped between February 9 and 22, the final shipments going forward on verbal orders before the second written contract was received.

* * *

A quantity of Bolt forgings and Slide forgings were supplied to both the National Postal Meter Company and Quality Hardware & Machine Corporation, during 1943 and 1944. The orders for these were apart from the orders for the machined parts. Some of the forgings were made at the Company's plant, while others were made by the Westinghouse Air Brake Company, on purchase orders from the Company. These orders, dates, shipments, and notation as to producer of the forgings, follow:-

National Postal Meter Company

Item & Amount	Order Date	Shipments Made:	Forged by:
Slide: 5,000	9-3-43	9-10 to 9-17-43	WABCO
" 10,000	9-21-43	9-29 to 10-5-43	"
" 50,000	2-1-44	1-27 to 3-2-44	"
Bolt: 24,000	2-1-44	2-5 to 2-12-44	US&S

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(Continued next page)

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

CONTRACT HISTORY - (Con't.)

Quality Hardware & Machine Corp.

Item & Amount		Order Date	Shipments Made:	Forged By:
Slide:	15,000	9-2-43	9-15 to 9-22-43	WABCO
"	10,000	10-9-43	10-16 to 10-20-43	"
"	10,000	11-1-43	11-23 to 12-2-43	"
"	32,238	1-8-44	1-8 to 2-21-44	"
Bolt:	5,000	9-10-43	9-11 to 9-15-43	US&S
"	5,000	11-1-43	11-12-43	"
"	2,000	12-6-43	1-12-44	"
"	20,000	12-13-43	1-12 to 2-13-44	"
"	24,000	1-8-44	2-18 to 3-20-44	"
"	16,415	1-13-44	3-15-44	"

* * *

GENERAL REMARKS ON CONTRACTS:

Immediately upon receipt of the contracts for the production of the Bolts, Slides and Receivers -- in February, 1943 -- several key employes of the Company were sent to plants of other prime producers of the Carbine to observe manufacturing techniques, while management representatives also visited plants of various producers including those of the National Postal Meter Company, International Business Machines Corporation, Inland Products Company and Underwood-Elliott Fisher Company.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS ON CONTRACTS - (Con't.)

Delivery of tools, fixtures and gages was promised for May 1, 1943. Much of the material, however, was not received until several months later, and then found to be unsatisfactory, so that the Company was forced to make many of its own gages.

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Establishment of the method of manufacture was turned over to the engineering staff of Quality Hardware & Machine Corp., one of the prime contractors, so that the manufacturing techniques to be followed by the Company, would be in accordance with those employed at the contractor's plant. This would have been entirely satisfactory if all the pieces produced had been destined to this one contractor. It was found, however, that while some of the parts were acceptable -- in the main -- to one of the contractors, more than 80% of the same part shipped to another contractor were rejected, although the parts conformed in manufacture to the specifications, and had passed three Company inspections and an Ordnance Department inspection.

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Another source of difficulty in production was the fact that the Carbine was constantly being re-designed throughout the period of manufacture. The many mandatory changes in design ordered by the Ordnance Department thus constituted a continuing problem, and also helped to

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS ON CONTRACTS - (Con't.)

prevent fulfillment of production schedules. The use of the Government-owned machines which had been used in manufacture of the .45 Caliber Automatic Pistol, was found to be unsatisfactory. This practice had been advised against by the Company, but orders were given that the machines were to be used insofar as possible. Many of the machines proved incapable of performing the functions demanded of them and had to be replaced -- with consequent further delay.

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Despite these difficulties, however, rejections on a total of 111,853 Bolts that had been shipped up to a certain period during production, were held to 1.4%. Rejections on 130,205 Slides, also shipped during this period, were held to one-half of one percent, while rejections on Receivers shipped to one prime contractor were held to less than one-half of one percent -- although another prime contractor rejected as high as 80% of the Receivers shipped to it.

* * *

MANUFACTURING OPERATIONS AND DIFFICULTIES:

The Receiver. Made from hot-rolled, special molybdenum alloy steel, the piece was cut to length -- (6.750" Plus/Minus .010") -- from 1 9/32" x 1 9/16" bar stock. It was heat-treated, then ground

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

MANUFACTURING OPERATIONS, etc., - Receiver - (Con't.)

on a disc grinder to establish a working point. It next received a final grind on two sides to 1.215" with a tolerance of Plus .000" / Minus .005". The sides had to be parallel within .001".

Then followed the rough and finish milling -- two pieces at a time -- of both contours, after which a .560" hole was drilled at one end. This last operation was performed on a gun-drilling machine which had been used in production of the .45 Caliber Automatic Pistol.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

After facing and counterboring, milling the rear sight slot, rough milling of a hook on the front and back of the sight boss, and rough milling of the ejector opening, a .277" hole was drilled. Then a .381" step, and a .125" radius was milled, after which came the finish profiling of the 22° side of the ejector opening.

Three more operations -- originally performed separately but worked out by the Company so that they could be done at one setting -- followed. These were the finish milling of the front and bottom, and rough milling of the back; profile milling left side of the ejector opening, and profile milling of a .283" dimension. The front lug then was straddle-milled -- two pieces at a time -- followed by straddle-milling of the recoil plate catch, and straddle-milling of the rear lug; cutting of a slot in the lug and cutting a .125" radius on the coil spring housing came next.

MANUFACTURING OPERATIONS, etc., - Receiver - (Con't.)

Other operations included:- Drilling .124" retainer hole in back end; milling .180" x .140" slot; milling .200" radius; side-milling 19° angle on recoil plate catch; form-milling hook on rear where the Receiver catches into the stock of the Carbine; form-milling .5400" radius on front end where barrel screws into Receiver; finish milling of .500" radius on front; drilling and then reaming, .180" hole in trigger guard front lug. This last operation gave much trouble at first because of a tendency of the piece to spring. This was overcome by a re-designing of the fixtures.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Various slots, undercuts, chamfers and radii then were milled. There were many closer tolerances to be observed in the machining operations, one dimension of .170" having a Plus/Minus of .002". On another dimension the tolerance was Plus/Minus .0005".

One of the final operations -- and one that gave much trouble when production began -- was the milling of a thread in the front of the piece. This called for a thread of .7175" pitch diameter, blending of the ends of the thread, and holding it to a Class III fit. Index lines on the Receiver and Barrel also had to match exactly, which meant that the thread had to start at a certain point.

Approximately 80 operations were performed on the Receiver, which, at final inspection, received 34 gage inspections.

MANUFACTURING OPERATIONS, etc., - (Con't.)

The Slide. This piece was machined from a forging made from an alloy steel with a molybdenum content, the forgings being made both at the plant of the Company, and at the plant of the Westinghouse Air Brake Company. After being trimmed, cleaned, and ground for locating surfaces, the bottom of the piece was contour-milled, and the ends rough milled, giving it a length of 7.211", Plus .010"/Minus .000".

Some 37 machining operations in all were performed on the Slide, including contour milling of the right side, top and back end; straddle-milling of various radii, contour milling of the left side, rough and finish milling of the gas cylinder clearance, and milling of various slots.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

One operation -- requiring great care and precision -- was the rough and finish milling of a .254" lead. This lead operated the Bolt, as the Slide moved back and forth.

At the conclusion of the machining operations -- and in addition to various inspections during processing -- there were some 11 gage inspections and a Rockwell hardness test.

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The Bolt. Containing material for two pieces in one forging, this also was made of an alloy steel with molybdenum content. After partial

MANUFACTURING OPERATIONS, etc., - Bolt - (Con't.)

machining the piece was cut off. The preliminary operations included rough turning to .590" diameter; facing of both ends and backs of lugs; drilling, reaming and finishing of the firing pin holes, and putting a 60° bevel in the back of each firing pin hole, to be used as a center. The piece then was cut off and finish ground to .556" diameter -- Plus .0000"/Minus .0005".

Work on the lug was finished, after which various radii were milled and the ends milled. Then came the drilling of the ejector hole. This had to be held on the center-line within .003". The ejector hole then was reamed. Some bench operations followed, after which the Bolt was heat-treated and given a Dulite finish. On the final inspection some 23 gaging operations were performed.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

* * *

GENERAL REMARKS ON THE CARBINE PARTS:

Although a delay of some six weeks elapsed between the termination of the contract for production of the .45 Caliber Automatic Pistol, and the establishment of a production line for the Carbine parts, some 800 workers -- (approximately 75% of whom were women) -- were retained from the Pistol job for work on the Carbine parts. These workers included all supervisors and set-up men.

GENERAL REMARKS ON PARTS - (Con't.)

Operations were conducted seven days a week, and at peak production approximately 2,000 Receivers, 2,000 Slides and 1,850 Bolts were being produced each day.

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Supervisory personnel was trained at the Company's plant, but throughout the life of the contracts, lack of an adequate number of supervisors constituted another problem for the Company -- especially in the training of the various production crews when changes were made due to the re-designing of the Carbine.

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It was found -- as early as November, 1943 -- that in production of the Slides, changes in tools had been required on eight operations; fixtures had to be changed, re-designed or replaced on 10 operations, and gages on four operations were incorrect as received. For the Bolt, changes in cutting tools were required on 11 operations; fixtures had to be changed, re-designed or replaced on 21 operations, and gages on six operations were incorrect as received. In production of the Receiver, tool changes had been required on 12 operations; fixtures had to be altered, re-designed or replaced on 33 operations, and gages for 15 operations were incorrect as received.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
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GENERAL REMARKS ON PARTS - (Con't.)

Added to these difficulties was the wear-life of the gages. Some plug gages were good for only 200 pieces, while many of the smaller gages had to be replaced at least once each shift.

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Since the Company had to meet the inspection requirements of three prime contractors, and those of the Ordnance Department, more rigid tolerances had to be observed than those set up in the specifications.

- - -

Ordnance Department officials were untiring in their efforts to expedite the procurement of machines, tools, gages and the fixtures needed to achieve the Company's production quotas. In addition the Company stationed one of its representatives at the plant of the Quality Hardware & Machine Corp., for the sole purpose of expediting delivery of gages and fixtures by this firm.

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No new construction was required for the department in which the Slides, Bolts and Receivers were produced. Existing floor space was used, some 57,000 square feet being assigned to the department.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

DIAL WHEELS FOR TELETYPE MACHINES

(U. S. Navy Contracts)

--o--

Company, Rounding Out Fourth Contract, Has Shipped More Than 594,000 Assembled Units in Twenty-eight Months -- Average of 1,200 Units Produced Daily by All-Women Crews -- Company Developed and Perfected All Tools, Jigs and Electric Test Devices -- Many Problems in Manufacture are Overcome

--o--

Under four contracts with the United States Navy -- the first awarded in January, 1943, the last in March, 1945 -- The Union Switch & Signal Company produced and shipped -- (up to October 31, 1945) -- a total of 594,260 Dial Wheels, used by the Navy on teletype machines to send messages in code. The wheels are packed in special metal containers in sets of 10 assembled wheels. Two sizes of wheels were produced -- the Mark III (small), and the Mark II (large). It was on a contract for 10,000 sets of the latter type Dial Wheel that the Company was still engaged in production on November 1, 1945.

The number of sets of each size Dial Wheel shipped, up to October 31, 1945, was divided as follows:-

Mark III (small) Dial Wheels - 20,192 sets (*)

Mark II (large) Dial Wheels - 39,234 sets

(*) Includes an "overage" of 192 sets shipped November 24, 1944.

* * *

DESCRIPTION OF THE UNIT:

Each Dial Wheel consists of two moulded bakelite discs. One has the 26 letters of the alphabet engraved on the periphery, the other is plain. These discs are attached to either side of a steel feed wheel. The Mark III Dial Wheels -- no longer produced by the Company -- were 3.5" in diameter, the Mark II Dial Wheels are 3' in diameter.

The bakelite discs -- since the Company undertook the first contract -- have been moulded at the plant of the Westinghouse Air Brake Company, Wilmerding, Pa., under sub-contracts from the Company. Moulded into each disc are small, tin-plated, beryllium-copper contact-connectors, one for each letter of the alphabet.

The steel feed wheel -- manufactured complete at first by the Company -- now has the outside diameter machined, and twenty-six teeth cut into the periphery, also at the plant of the Westinghouse Air Brake Company. The steel stampings for the wheel are furnished by The Union Switch & Signal Company.

* * *

HISTORY OF THE CONTRACTS:

First Contract. On December 19, 1942, a representative of the United States Navy Department visited the Company's plant at Swissvale, Pa., to discuss production of Dial Wheels in the Mark III and Mark III sizes. A quotation on the production was made January 8, 1943, with a contract being received on January 25. This contract called for 20,000 sets of the Mark III size Dial Wheel, and 15,000 sets of the Mark II size.

A sub-contract for the moulding of the discs for the two sizes was given the Westinghouse Air Brake Company on February 11, 1943. It called for 204,000 each of the plain and lettered discs for the

CONTRACT HISTORY - (Con't.)

Mark III Wheel, and 153,000 each of the plain and lettered discs for the Mark II Wheel. The first delivery of the Mark III plain discs was made to the Company on June 7, 1943, with first deliveries of the Mark III lettered disc on June 15. This enabled the Company to make its first deliveries -- in the amount of five sets, or 50 complete Wheels -- to the Navy on June 30, 1943.

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PRODUCTION
OF
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The first of the Mark II plain discs was received by the Company on May 27, but the first of the Mark II lettered discs was not received until July 23. The first shipment of the Mark II Dial Wheels was made to the Navy by the Company on August 25, 1943, in the amount of 24 sets, or 240 Wheels.

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Other shipments of the Mark III Dial Wheels were made in varying amounts during the next fifty-three weeks, the contract for the 20,000 sets being completed with a shipment of 30 sets on July 6, 1944, a little more than three months behind the schedule of deliveries set up at the time the contract was awarded. Similarly, the final shipment on the order for 15,000 sets of the Mark II Wheel, was made almost three months behind schedule, going forward on May 26, 1944.

CONTRACT HISTORY - (Con't.)

During this first contract, peak shipments during any one month of the Mark III Dial Wheel, were made in January, 1944, when 2,651 sets were forwarded. For the Mark II Dial Wheel, peak shipments were made in April, 1944, when 2,717 sets were sent out.

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Second Contract. A telephonic inquiry regarding additional production was received by the Company on May 15, 1943, quotations being forwarded on May 29. A contract -- calling for 8,250 sets of the Mark II Dial Wheel -- was awarded June 30. Deliveries were to be made "at the rate of one hundred (100) sets per day starting upon completion" of the first contract.

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The first shipment, however, was made on June 12, 1944, in the amount of 1,437 sets. A total of 3,000 sets in all -- the peak number shipped for any one month under the Second Contract -- went forward that month. The last shipment, in the amount of 343 sets, was made on September 29, 1944.

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Third Contract. This contract -- for 9,000 sets of Mark II Dial Wheels -- was received on June 10, 1944, following inquiries made on May 29, and quotations made on June 3. The schedule called for the

CONTRACT HISTORY - (Con't.)

delivery of "120 sets per day commencing in September, 1944, and continuing at that rate until delivery is completed."

The first shipment was not made until October 4, 1944, however, but a total of 1,752 sets was sent forward that month. During November, 1,680 sets were shipped. Final shipment on the contract was made on February 27, 1945, monthly peak shipments of 2,016 sets having been made during January, 1945.

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Fourth Contract. On January 30, 1945, the Company was asked by the Navy to submit quotations on production of another 10,000 sets of the Mark II Dial Wheel. Quotations went forward on February 9, and the contract was awarded on March 6, following receipt of a letter of intent on February 26. Shipments were to be in the amount of 2,000 sets a month starting in May, 1945. The first shipment -- of 432 sets -- was made on June 4. Up to August 31, 1945, a total of 4,832 sets had been shipped, while 1,432 sets were shipped in September, and 720 sets in October, for a total -- up to October 31 -- of 6,984 sets.

* * *

METHOD OF PACKING DIAL WHEELS

CONTRACT HISTORY - (Con't.)

"Overage" and Spare Part Contract. A considerable quantity of material was left over from the completion of the first contract. In June, 1944, the Company instituted negotiations for the purchase -- by the Government -- of this "overage" material. On October 3, 1944, a contract for the purchase of 192 sets of Mark III Dial Wheels -- complete with containers -- 6,639 of the plain bakelite discs and 539 of the lettered discs for the Mark III Wheels, together with 15,000 screws used in assembling the Mark III Wheels was awarded.

PRODUCTION OF WAR MATERIEL 1940 - 1945
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Also included in this contract was the purchase -- by the Government -- of 50,000 each of the plain and lettered bakelite discs, and 50,000 of the screws used in assembling the Mark II Wheels. This latter material also was "overage" from the first contract.

Delivery of the first four items was to be made "within 30 days after date of contract," and of the last three items, "within 90 days after date of contract." The plain and lettered discs and screws for the Mark III Wheels went forward on November 16, 1944, while the 192 sets of Mark III Wheels were delivered on November 24.

The other items were delivered between March 3, and May 24, 1945.

* * *

MANUFACTURE OF THE DIAL WHEEL:

As moulded by the Westinghouse Air Brake Company, each bakelite disc contains 26 tin-plated, beryllium-copper inserts, which are so formed as to be used both as contacts and connectors. After moulding, trimming, etc., the discs are rough-ground, then shipped to The Union Switch & Signal Company. Here they are finish-ground to a true plane. This finish grinding presented difficulties at first, this being discussed later on in this report.

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Four .234" holes are drilled and countersunk in each disc. These are for the screws to fasten the disc to the steel feed wheel. The holes are tested with gages, after which the discs have excess bakelite scraped from the connectors and are given a visual examination. In the case of the discs bearing the letters of the alphabet on the periphery, dirt and grease are removed from the letters which then are filled with white paint. The excess paint is removed from all surfaces. Both types of discs then are given a final cleaning and polishing.

In assembling the plain and lettered discs to the steel feed wheel, a special jig is used, the discs being located in proper relationship to each other and to the feed wheel by means of bosses moulded on the outside diameter. Four screws are driven home into the feed wheel through each disc, an air-powered driver with floating chuck being used.

MANUFACTURE OF THE DIAL WHEEL - (Con't.)

After further inspection and cleaning to remove metallic flakes and dust, the assembly is given a 30-ampere test for broken connections, each side being so tested. The machine used for this test was devised and developed by the Company. Then follows a 500-volt test for short circuits. This test machine also was devised and developed by the Company for this particular item of production.

Plug, feeler and snap gages next are used, after which the Dial Wheel is inspected for proper positioning of the hub in the steel feed wheel, and for run-out. A maximum wobble of .015" is allowable. By means of another device developed by the Company excess wobble may be corrected.

PRODUCTION OF WAR MATERIEL 1940 - 1945

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MANUFACTURE OF THE FEED WHEEL:

When the Company started production of the Dial Wheels, it manufactured the steel feed wheel in entirety. Blanked out from 1/8" sheet steel, three spokes on the wheel are swaged, a center hole is reamed and the blank is copper-plated. Then 26 teeth are cut on the periphery, these teeth being case-hardened. Eight holes are drilled at pre-determined positions, the holes then being tapped. The teeth are wire-brushed to remove burrs after which the wheel is chromium plated.

MANUFACTURE OF THE FEED WHEEL - (Con't.)

Then follows inspection of the feed wheel for nicks, burrs and faulty plating; the cleaning of a brass bushing-and-collar, and the affixing of the latter piece to the feed wheel with another brass collar. Both the collar and the bushing-and-collar are manufactured by the Company. The outside diameter of the bushing is serrated. The collar is pressed home, and then is spun on to the bushing and countersunk so as to form a hub. This hub then is reamed and faced, and the entire assembly is countersunk and finish-reamed. For the Mark III Wheels, an Oilite bushing also was used.

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All of the feed wheels used on the Mark III Wheels, and some 50,000 of the Mark II feed wheels were manufactured by the Company before the work was sub-contracted to the Westinghouse Air Brake Company which -- since November 16, 1943 -- has machined the outside diameter and cut the teeth. All other operations on the feed wheel are performed by the Company within its plant. The teeth -- each 1/8" x 1/8" -- are cut to a depth of 1/16", and are spaced 9/16" apart.

* * *

The Dial Wheels, when finally inspected and passed, are packed in sets of ten in special metal containers purchased by the Company. A name plate -- also purchased -- is affixed to the container which then is packed in a heavy cardboard carton for shipping.

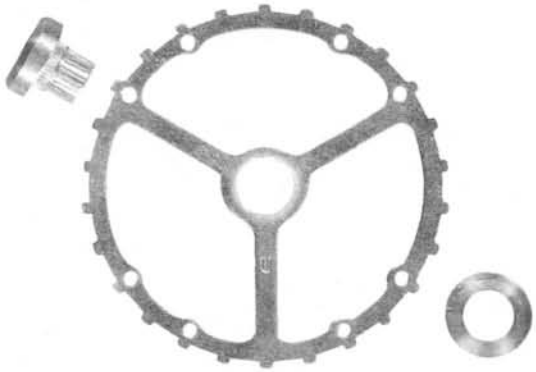
BLANK

MACHINED

TEETH CUT

STEEL FEED WHEEL

TAPPED AND PLATED



FEED WHEEL ASSEMBLY PARTS

COMPONENT PARTS OF ASSEMBLY

ASSEMBLED

MARK II DIAL WHEELS

All screws used in assembling the bakelite discs to the steel feed wheels were manufactured at first by the Company, but since the filling of the first contract have been purchased from outside sources.

* * *

MANUFACTURING DIFFICULTIES - Bakelite Discs:

One of the most difficult operations in the manufacture of the Dial Wheels was the finish-grinding of the bakelite discs into each of which 26 beryllium-copper contact-connectors had been moulded. These discs are furnished rough-ground by the Westinghouse Air Brake Company, an allowance of .004" being provided for finish-grinding.

The first attempts at finish-grinding by the Company resulted in trouble, it being found that the grit of the wheel used -- (a #60) -- was too coarse. Because the metal of the contacts was harder than the bakelite there was a tendency to rip out the bakelite between the metal parts. This was especially true in the case of the Mark III Dial discs where the contact-connector surfaces to be ground were closer together. A #80 wheel next was used, but the same trouble resulted. Constant experimentation resulted in the adoption of a Crystalon L91 wheel -- a very fine hone -- which has since been used for this operation. This has given an exceptionally fine finish to all discs.

* * *

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MANUFACTURING DIFFICULTIES - Feed Wheel:

The cutting of the teeth on this wheel presented some difficulty at first, but the greatest problem was in securing a perfect chromium plating. This was solved by the designing and manufacture of a special type of plating tank and contact. In this tank each wheel is plated to a depth of .003" on each surface. The special sliding contact removes the "scoring" effect at first encountered. Each wheel is immersed in the plating bath for 17 seconds, being kept in constant motion during that time, thus securing an even distribution of plating.

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS:

The Company designed, developed and manufactured all special tools, jigs, gages and electrical equipment used in production of the Dial Wheels. Some few extra machines had to be purchased. These included three drill presses; three second-hand rotary grinders and one arbor press. When necessary the machinery was adapted to perform specific operations.

One entire section of the plant was set aside for the Special Development Department in which the Dial Wheel is produced. This approximates some 2,000 square feet. Entrance to this section is rigidly controlled, none but authorized employes, or officials, being admitted.

GENERAL REMARKS - (Con't.)

The Department -- at full strength -- consists of 78 women, and operates on a three-shift, six-day week. Production approximates an average of 1,200 complete Dial Wheel assemblies per day. In addition to the women employes, five or six men as supervisors, or as grinders, work on production of this item.

Assembly work and inspections are performed entirely by women, most of whom had to be trained for their particular tasks, they having had almost no experience in factory work. Some-- already employed by the Company and shifted to this department -- had to acquire new skills. The work of inspection is performed by two Company employes who check each detail, after which representatives of the Navy Department conduct the final inspections.

So thorough has been the work of this department that samples of the Dial Wheels -- (Mark III) -- sent to the Naval Testing Laboratory, were pronounced "as good as, or better than" similar Wheels produced by a competing facility. This report was made even after a million cycles test operation.

There have been no reports of any of the units produced by the Company ever having been rejected or found faulty in test.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

GENERAL REMARKS - (Con't.)

Some delay in the initial production of the Dial Wheels was experienced because of difficulty encountered by the Company in securing the few extra machines needed to successfully handle the production. Material shortages -- over which the Company had no control -- also proved a hindrance from time to time.

The Company supplies the Westinghouse Air Brake Company with the beryllium-copper contacts which are moulded into the bakelite discs. At the beginning of the contract one company making these items did not produce them to drawing. This led to delay. However, most of the causes for delay had been overcome by the beginning of 1945.

Following the announcement of the capitulation of Japan in August, 1945, there was some belief that the Fourth Contract might be cancelled. In fact shipments of Dial Wheels were held up for the four days from August 23 to 27, but then were released and have continued regularly since that time.

* * * * *

ORDERS FOR PLAIN HALVES OF MARK II CONTACT RINGS

During four months of 1943, while the Company was engaged in filling Navy Department orders for Dial Wheels, the Company also produced a total of 30,702 moulded - plain halves - of the Contact Ring for the

PRODUCTION OF WAR MATERIEL 1940 - 1945
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Mark II Dial Wheel, supplying them to L. C. Smith & Corona Typewriters, Inc., Groton, N. Y. Four screws for each half, also were supplied.

The first order was received on April 16, 1943. It was for 14,700 pieces, to be shipped at the rate of 2,100 a week commencing May 1. The first two pieces went forward on May 17, the last shipment -- of 1,230 pieces -- being made on July 19, 1943. These pieces were intended for use by the Army on a joint Army-Navy project on which L. C. Smith & Corona Typewriters, Inc., was the prime contractor. A total of 14,702 pieces was supplied on this first order.

The second order -- for 16,000 pieces -- was received June 18, 1943. These were to be shipped at the rate of 2,000 weekly, beginning July 1. The first shipment -- of 600 pieces -- was made July 8. The last shipment -- of 1,300 pieces -- was made on August 30, 1943.

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PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

DEVELOPMENT AND PRODUCTION OF THE "AZON" (AZ-1)

or,

TAIL ASSEMBLY FOR HIGH-ANGLE, DIRIGIBLE BOMBS

--o--

Design and Component Parts of Original Trial Units Materially Changed by Company -- Many Substitutions of Materials or Parts Necessitated Before Reliable, Effective Assembly Could be Produced on Quantity Basis -- Company Given Order for 10,600 Assemblies Even Before First 200 Units Ordered Had Been Given Field Tests -- Additional Orders for "Secret and Confidential" Weapon of World War II Received After It Had Demonstrated Its Value Against Enemy Installations

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One of the "secret weapons" of World War II used by the United States Army Air Forces to increase accuracy of bombs of 1,000 pounds or over, was a device known as the "Azon", or AZ-1. This is a tail assembly for high-angle, dirigible bombs, the use of which increased the precision of bombing. The improvement was such that -- on long, narrow targets, such as bridges -- the "Azon" was 20 to 40 times as effective as standard bombs. The Union Switch & Signal Company was the first quantity producer of the AZ-1, and to the Company belongs the credit for the refinement of its parts, the incorporation of many devices increasing its efficiency, and its development permitting of quantity production.

> Controlled by radio, the "Azon" was used to destroy the Avisio Viaduct near Rome, and to cripple German supply lines through the Brenner Pass, and also in Burma. However newer devices soon made the "Azon" out-moded, although the theory behind the radio-guided and directed aerial missile, was applied to larger weapons of the same general type -- in the development and production of which The Union Switch & Signal Company also pioneered. Discussion of one of these weapons -- the "Razon" is contained further along in this report.

Although the theory of the AZ-1, and the first test pieces were developed by the Massachusetts Institute of Technology, and by the Gulf Research and Development Company -- the latter of Harmarville,

Pa. -- the task of the further development, both in design and for quantity production, was entrusted to The Union Switch & Signal Company, by the National Defense Research Committee of the Office of Scientific Research and Development. This was early in 1943.

Before the end of 1943 -- and even before all of the original order of 200 test units had been delivered by the Company under the OSRD order -- the Company was in receipt of an order from the Army Air Forces, for 10,600 units.

(A somewhat larger edition of the same unit, designated)
(the AZ-2, also was developed by the Company, although)
(it did not go into quantity production, being restrict-)
(ed to construction of 132 test units.)

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Since full details as to engineering and construction of the AZ-1 have not been released, the following report does not go into great detail on these matters. Such information is contained, however, in the records of the Special Engineering Department of The Union Switch & Signal Company.

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The designation of the item as "Azon" is for the purpose of giving it a shop name, yet one that indicates, to a degree, its purpose. The name "Azon" is coined from the two words "azimuth" and "only" indicating that a bomb equipped with the unit can be controlled -- to the

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

left, or to the right, along the azimuth, in a plane parallel to the flight of the bombing plane -- during free fall.

This control of bombs equipped with the AZ-1, is in the hands of the bombardier. The AZ-1 incorporates a radio receiver, which picks up impulses from a radio transmitter locating in the bombing plane, and operated by the bombardier. "Left rudder" or "right rudder" or "dead center" are the three controls. Built into each AZ-1 also is an electrically-powered gyroscope which assumes "roll" control of the bomb at the instant of release. Servo motors, actuating the rudders of the AZ-1 in response to impulses sent out from the bomber's transmitter, which impulses are picked up by the receiver in the AZ-1, also are contained in the unit assembly. The ailerons of the AZ-1 are controlled by the gyroscope.

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Other parts built into the assembly include storage batteries delivering 24 volts for several minutes. This voltage powers the gyroscope, operates the motors, etc., while solenoids, a receiving antenna, and other items all essential to the proper functioning of the AZ-1, also are self-contained in the unit.

The bomb-- although freed from any physical contact with the bombing plane after it is released -- still is controlled from the bomber along a plane parallel to the direction of flight of the bomber at the instant the bomb is freed. A flare -- attached to the assembly and ignited several seconds after the bomb has fallen free -- permits the bombardier to follow the flight of the bomb, and thus observe

whether the bomb shall be directed to the left or the right to center it on the target. The AZ-1 -- being a part of the bomb itself -- is destroyed by the explosion at the target.

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As previously stated, the original development, and the construction of the first trial units of the AZ-1, were projects carried on by the Massachusetts Institute of Technology, and by the Gulf Research and Development Company. The theory of radio control of a free-falling bomb having been worked out and proven practical, the item was turned over to The Union Switch & Signal Company for further development -- both as to detail and for quantity production.

This was early in June, 1943, the Company receiving a letter of intent for a contract for production of 200 tail assemblies for test purposes. (This is to be found in the Company's records under OEMer-1081 -- US&S GO 506350.) The letter of intent was dated June 19, 1943. It was extended from time to time until May 31, 1945. Under this contract the first shipment of the trial, or test, units, was made November 25, 1943. Other shipments went forward from time to time until the order was completed with the shipment of 32 units on March 8, 1944.

* * *

Considerable experimentation went forward in the Company's Special Engineering Department, both in the matter of production, and with the items of control. One development of the Company was that of the "kick-off" switch. This -- located on the side of the housing of the assembly -- serves to transfer the apparatus from the ship's power to the battery within the bomb's tail, the switch plug being "kicked" free from the housing at the moment the bomb is released from its rack in the bomb bay of the plane. The plug, on its cable, is thrown free and the power then is furnished from the set of storage batteries located in the tail assembly.

PRODUCTION OF WAR MATERIEL 1940 - 1945

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Proportions and details of the AZ-1 had to be redesigned so as to make quantity production feasible. The department set aside for this work was placed under special guard, and admittance was restricted. The workers assigned to this department were not only among the most skilled in their line, but were those who were among the most trustworthy. While certain of the items entering into the Assembly of the AZ-1 were fabricated in other sections of the Company's plant, and some of the other work was done elsewhere outside the Department, all assembling and testing was done in the Special Department. Outside this Department special guards were maintained on 24-hour duty. All persons entering and leaving the Department had to sign in or out.

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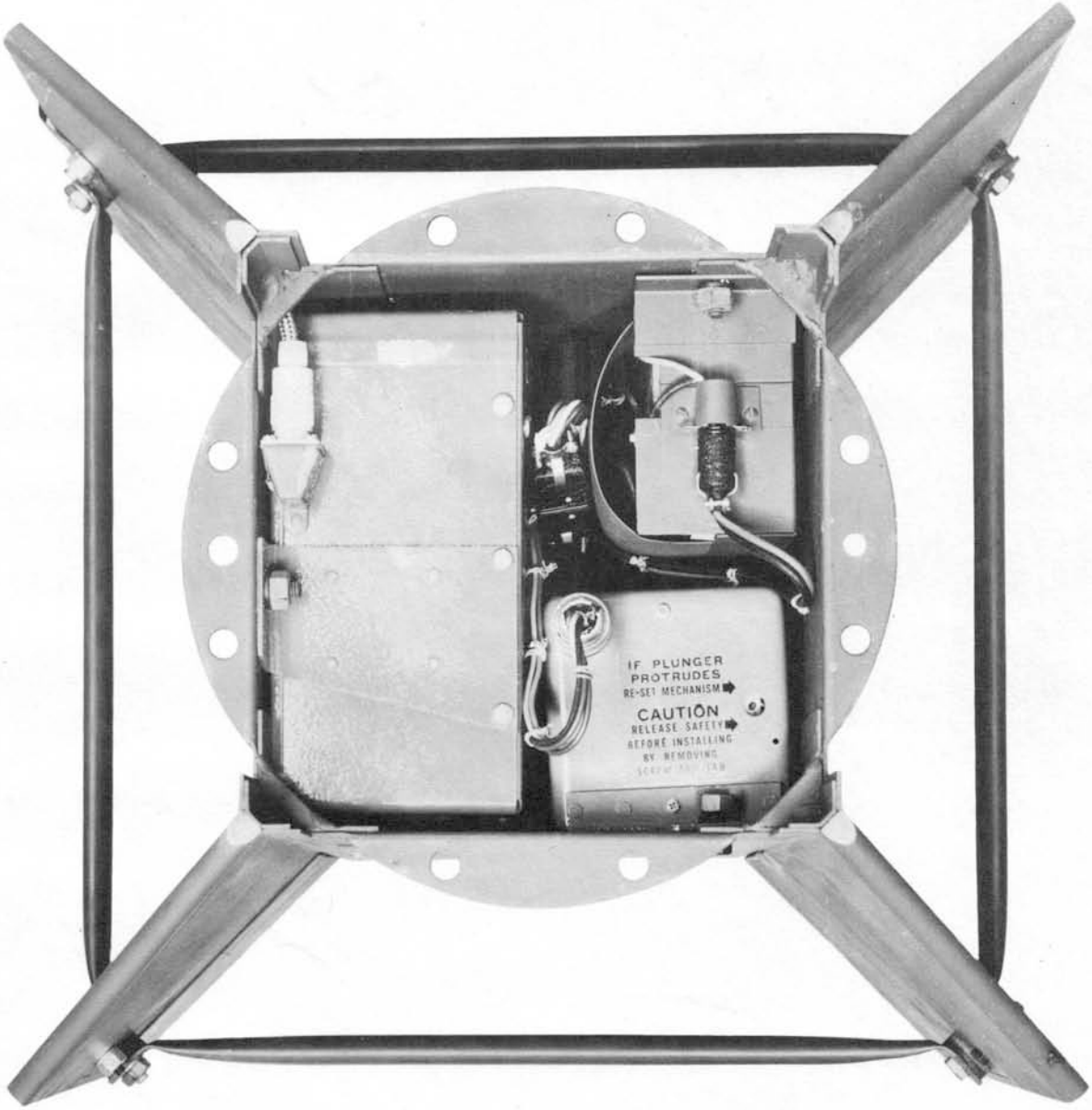

AZ-1, or "AZON"

View of Mechanism and Plate
by which Device is Attached
to Sleeve Fitting on Rear
of Bomb

In re-designing the assembly, the Company changed the device from a cylindrical body -- originally intended to fit a certain type of bomb -- to a square container. Special fasteners to attach the assembly to the tail of a 1,000-lb. bomb also were devised. An electrically-driven gyroscope was substituted for the air-driven gyroscope which had been used in the original assembly developed by the Massachusetts Institute of Technology and the Gulf Research and Development Company.

One drawback to the use of the air-driven type of gyro was that once the bomb was released, the gyroscope no longer was powered. Hence it "coasted" from its original speed in a gradually decreasing number of revolutions per minute. This decrease -- gradual though it was -- was felt to be a handicap in the time lapse of perhaps some thirty to forty seconds between release of the bomb from the plane to moment of impact of the bomb on the target. Other reasons also necessitated a change from the air-driven gyro. Electric powering of the gyroscope was important to make certain it would start when cold.

The electrically-driven gyro was brought up to speed by power from the ship. The electrical energy -- when the bomb was released -- then was supplied by the discharge from the storage batteries.

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Other changes included substitution of all-metal for metal-clad plywood for fins, ailerons and rudders. The plywood not only was subject to atmospheric changes, but was flimsy, and its use with metal

PRODUCTION OF WAR MATERIEL 1940 - 1945
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cladding made it difficult to fabricate and assemble. The fins -- once metal was substituted -- also could be made an integral part of each of the four sides of the square container.

Steamline-section steel tubing was used for struts and -- when insulated from the body of the unit -- served also as antenna for the self-contained radio receiver. In its latter capacity the tubing also did away with the use of the inverted-V type antenna used on the original development model.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

Control surfaces of the assembly were made hollow; shafts were one continuous piece, instead of being composed of cranks and links; the size of the fin projections was changed to providing dropping clearance between bombs hung on opposite bomb racks on certain types of planes. The manner of attaching the assembly to the bomb also was changed, while other developments permitted the assembly to be attached to bombs after the latter had been hung in the racks. A method of alignment -- to permit the directional gyroscope to function as intended -- also was devised.

A number of other features of the original model that were found to be objectionable -- both from functional and production standpoints -- as well as capable of hampering and delaying service of the assembly in the field, also were changed.

The gyroscope used in the AZ-1 produced by the Company -- as stated previously -- is powered from the plane until the instant of the bomb's release. At that moment the power source is transferred to the storage batteries in the tail assembly. These batteries also power the Servo motors which -- through relay contacts -- operate the rudders. The ailerons are operated through solenoids. The battery also fires the charge igniting the flare on the tail of the bomb.

The battery used in the original development model, delivered only 12 volts. It was decided to substitute 6-volt batteries in sets of four. Requiring only the addition of electrolyte in the field to make them ready for use, these battery sets deliver 24 volts, which agrees with the 24/28-volt power used on the planes.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

As the AZ-1 functioned -- as produced by the Company -- all preliminary operation of the components of the assembly, such as the pre-energizing of the gyroscopes and radio circuits, made use of the plane's power so that the storage batteries were not subjected to discharge in any way until the bomb was released.

The batteries adopted by the Company have ample capacity to operate the AZ-1 for several minutes at temperatures as low as -40° F. The warm-up circuit -- used before the bomb was dropped -- was energized while the plane was in flight and, through raising the internal temperature of the AZ-1 about 20° F. above the temperature in the bomb bay, increased the efficiency of the battery.

- - -

The radio receivers used on the development models responded to signals for "left" or "right" rudder by means of different impulses sent out from the transmitter in the bombing plane. This type receiver had certain drawbacks so that the receiver as used in the Company's original production models -- and as constructed according to the Company's development -- made use of two audio frequency modulated signals, transmitted by a standard Signal Corps RC-186 transmitter.

The AF signal for "left" rudder was 475 cycles, while 3,000 cycles was used for "right" rudder. The receiver development was undertaken by a radio manufacturer, and resulted in a set capable of being tuned to any one of five channels in the 80-90 megacycle band, and which -- when adjusted -- permitted control of the AZ-1 assembly from as high as 20,000 feet.

- - -

The Company also found it necessary to re-design the solenoids. It was decided to use two double-acting solenoids -- one for each aileron -- with couplings between the pairs.

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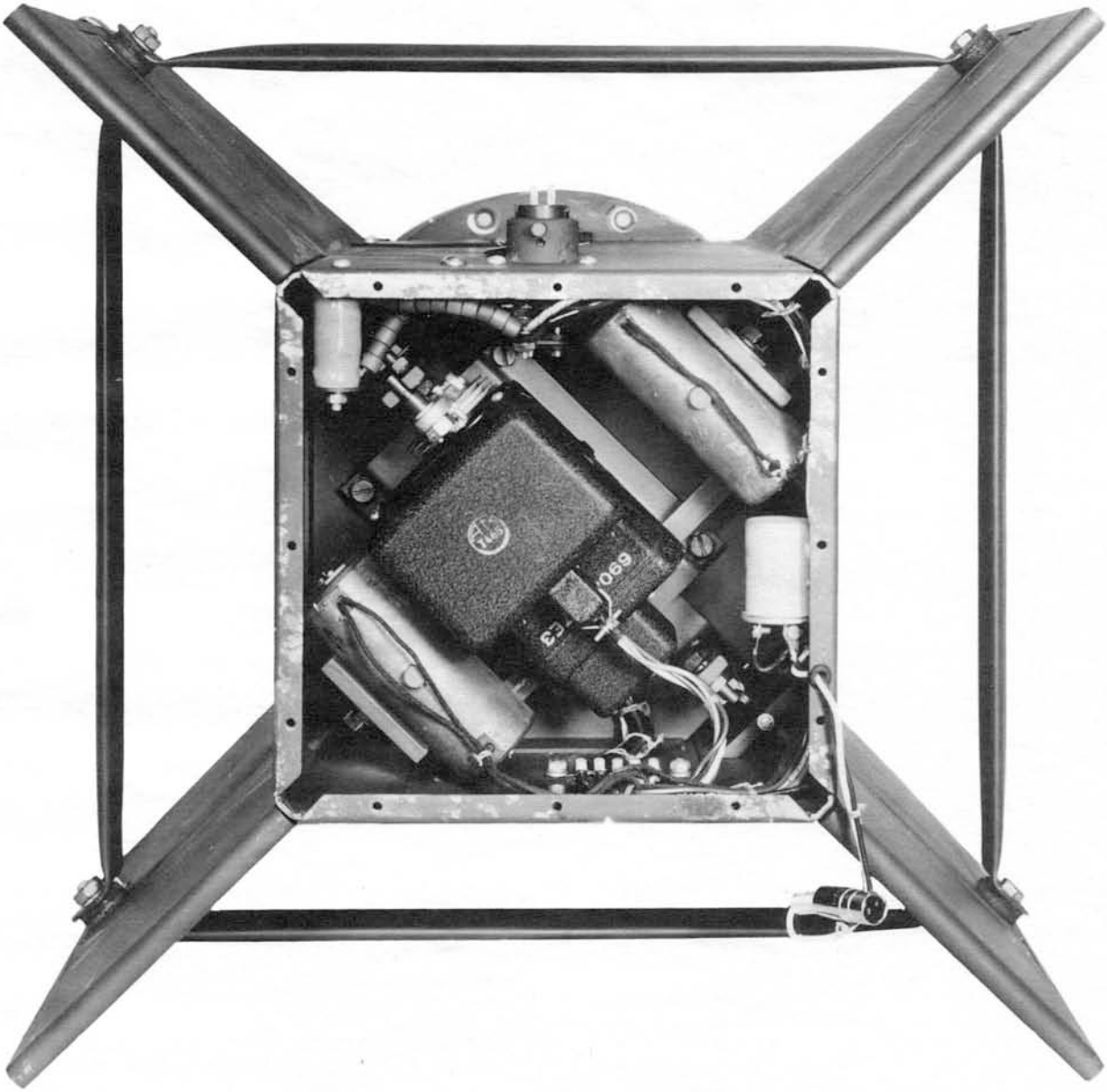
On the tail of the AZ-1 there is attached a flare. This -- as has been said -- permits the bombardier to follow the fall of the bomb. This flare -- developed by the Army Ordnance Department -- is



AZ-1, or "AZON"

View of Mechanism from Rear,
or Flare End, of Device

fired by the internal batteries in the assembly. After the bomb has been dropped, a built-in time relay provides approximately 8 seconds lapse between the time the bomb falls, and the ignition of the flare.

The circuits actuating the flare is separate from others in the assembly, and runs through the "kick-off" switch. It is controlled by the bombardier and cannon be accidently ignited.

- - -

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

During the warming-up period, the gyroscope is brought up to speed through use of the ship's power. At the instant the bomb is released, the gyroscope is uncaged and becomes powered by the batteries in the assembly. The gyroscope also assumes orientation of the bomb to keep the rudders in the proper plane before the bomb actually leaves the rack. The bombardier -- as has been said -- can direct the sideways fall of the bomb by means of the transmitting apparatus before him.

- - -

The "kick-off" switch -- previously mentioned -- is the means by which the AZ-1 tail assembly is connected to the wiring of the plane to secure the power to bring the gyroscope up to speed, to pre-energize the radio receiver and to change the battery. The same electrical impulse releasing the bomb, uncages the gyroscope at the instant of bomb release.

As developed by the Company, the "kick-off" switch consists of a number of contact springs held in an open position by a four-way plug. This, in turn, is held by an arming wire in a collar attached to the tail of the AZ-1.

When the "kick-off" plug is inserted in the four-way socket, four circuits are provided. One grounds the mechanism to the plane's ground. A second provides a path for the flare-arming relay. A third provides a circuit for pre-energizing the gyroscope, radio and battery charging. The fourth connects to the bomb release mechanism to provide the means for uncaging the gyroscope. When the bomb falls from the rack the arming wire is pulled and the plug is expelled from the collar. The cable to which the plug is attached is pulled out of the way by the resiliency of nylon cords to which it is attached.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

- - -

The Servo motors used in the AZ-1 have nominal speeds of 6.5 rpm. Such a speed is sufficient to operate the rudders of the assembly through an angle of 15 degrees in 0.6 seconds. It was determined -- through tests -- that from a height of 15,000 feet the bomb could be corrected by half a mile, or more, before impact.

- - -

In development of the AZ-1 for quantity production it was found necessary to provide some means to check the gyroscope operation. A

turntable arrangement, with the control points of the gyroscope marked on it in degrees -- and with switches to control the application of power to the motors and uncaging circuits -- was developed by the Company. A number of these turntables were sent to the Army Air Forces for field checking of gyroscopes immediately before they were inserted in the AZ-1 tail assembly for dropping.

- - -

A final test panel -- by means of which all functions of the AZ-1 may be checked -- also was developed by the Company. Switches and lights check all wiring, whether or not the radio receiver has been placed in position. Everything that can be is checked while the assembly is in the test rack. A number of these final test panels were purchased by the Army for distribution to the different theaters of operation so that personnel in charge of the AZ-1's could also check their operation in case of modifications made after the units had been received and unpacked.

* * *

CONTRACT HISTORY:

The first order for quantity production of the AZ-1 -- (then officially termed an Azon Tail Structure, Type AZ-1) -- called for 10,600 to be supplied to the Army Air Forces, Materiel Command, Wright Field, Ohio. Inquiries leading up to this order -- (US&S GO 510475) --

were initiated on October 25, 1943, even before the shipment of the first of the test units ordered by the Office of Scientific Research and Development. Quotation was made on November 24, and a letter contract for the 10,600 assemblies -- plus spare parts for the same -- was received by the Company on December 24, 1943. The formal contract, however, was not received by the Company until May 23, 1944.

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The Government, under the contract, obligated itself to supply the Company with one radio receiver -- Type An/CRW-2, or AN/CRW-2A -- and one sleeve assembly for each of the 10,600 tail structures.

- - -

A number of parts had to be purchased by the Company. These included the gyroscopes, Servo motors, storage batteries, battery syringes, and such things as nuts, bolts, screws, washers, connectors, etc. Other items including the solenoids, tail structure housings, etc., were fabricated by the Company. Approximately 200 different pieces entered into each assembly.

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The schedule called for shipments during January through June, 1944. Actual shipments were made between March 1 and August 19, 1944, in the amounts in the table to be found on the next page.

AZ-1s	Spare Parts (Gyroscopes	Servo Motors	Battery Sets	Syringes)
10,600	1,080	320	1,615	425

(One reason for the difference between the scheduled)
(and the actual dates of shipment was the difficulty)
(in the receipt of promised equipment from the Gov-)
(ernment, and parts from sub-contractors.)

- - -

Each completed tail structure was enclosed in a moisture-proof metallized-fabric bag and sealed, with containers of silica-get placed inside the bags. The package then was placed, and fastened, in plywood boxes for shipment. The same method of packing for shipment was used on subsequent contracts.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

- - -

The next order -- (US&S GO 521900) -- was received May 12, 1944. This was for 5,000 AZ-1 Tail Structures and spare parts. A supplement to this order -- calling for an additional 5,000 units and spare parts -- was received July 18, 1944. The schedule set up called for shipment of 3,000 each during September, October and November, with the final 1,000 in December, 1944.

On October 3, 1944, the Company received a telegram advising that the Government was going to terminate this contract -- as well as a succeeding one for 15,000 units -- as the items "were no longer needed

by the Army Air Forces." This telegram was signed by Lieutenant H. C. Finch, of the Air Technical Service Command, Wright Field, Ohio.

A total of 3,471 units, plus the necessary spare parts in ratio, were shipped on the second order -- (US&S GO 521900) -- between August 31, and October 10, 1944. Negotiations for cancellation charges on the work done on the balance of the contract plus parts and supplies ordered, were instituted by the Company.

- - -

The other contract for 15,000 AZ-1's and spare parts -- (US&S GO 524700) -- had been received by the Company on July 18. In this order the item was called a "Controllable Bomb Tail Fin, Type A-1", but other than in nomenclature, the item differed in no way from those previously produced by the Company. Deliveries were to have been made during October, November and December. Inquiries on this order were made on July 11, and quotations forwarded July 14, 1944.

- - -

Some five months passed during which time the Company heard that a new decision had been reached with regard to the AZ-1, and that more orders for their construction might result. Reports of the performance of bombs equipped with the AZ-1 tail structure had been studied and it was felt that in the device the Army Air Forces had a weapon of great value.

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On March 1, 1945, officials of the Army Air Forces asked the Company to again undertake manufacture of the AZ-1, in the amount of 1,000 units as a great need for them existed. The Company replied that it would take from 45 to 60 days to procure materials and again set up a production line, adding that it would take about the same period of time again, to produce the items. Some slight modifications in the device had been made.

An order for 1,000 units was received by the Company on March 23 -- (US&S GO 700). It was followed by a supplemental order and an additional 2,000 units on May 31. Up to July 1, 1945, approximately 700 units had been shipped on this order, under a schedule originally calling for 100 during May, 300 during June and completion of the contract in July. Later on, the supplemental order for 2,000 units was cancelled complete -- on August 17, 1945 -- while the last shipment on the order for 1,000, completing the order, had been made on July 24.

- - -

During the life of the first order -- (US&S GO 510475) -- the Company on several occasions and subsequently under other orders, made reductions in the price of the assembled AZ-1. These were due to savings through improvement in production methods, and lower costs for material and parts purchased by the Company.

* * *

Although the Company was the first facility in the United States to produce the AZ-1, some production was assigned to other facilities by the Army Air Forces, after initial production had gotten well under way. The Company was asked to make available to these other facilities its drawing and methods sheets, and complied with the requests.

- - -

Another producer of the AZ-1, was G. & A. Aircraft, Inc., of Willow Grove, Pa., a subsidiary of the Firestone Tire & Rubber Company, Akron, Ohio. A number of "kick-off" switches and plugs; indicator cups; receptacles; base plugs; covers; plates; washers, etc., were purchased from the Company. G. & A. Aircraft sub-contracted to its parent Company an order for solenoids, and the Firestone Tire & Rubber Company -- during the early part of September, 1944 -- made inquiries of The Union Switch & Signal Company, regarding supplies of solenoid coils. An order for 20,000 such coils was placed September 22. Actual shipment of 808 such coils had been made up to September 23 -- some having been forwarded before the contract was received -- when the order was cancelled "because prevailing conditions require cancellation," being closed out in the amount of 808 coils shipped. This cancellation came at the same time the Government cancelled the work being done by the Company on its first production of the AZ-1.

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PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

ENGINEERING DEVELOPMENT OF THE AZ-2

or,

Tail Assembly for

2,000-lb. High-Angle Dirigible Bomb

for the Army Air Forces

--o--

Item Engineered, and Total of 132 Test Units Produced and Shipped by Company Between June, 1944, and January, 1945 -- All Tests Satisfactory but Unit Never Produced in Quantity because Military Need for Item Had Diminished -- Contract for Development Awarded Company by National Defense Research Committee of the Office of Scientific Research and Development

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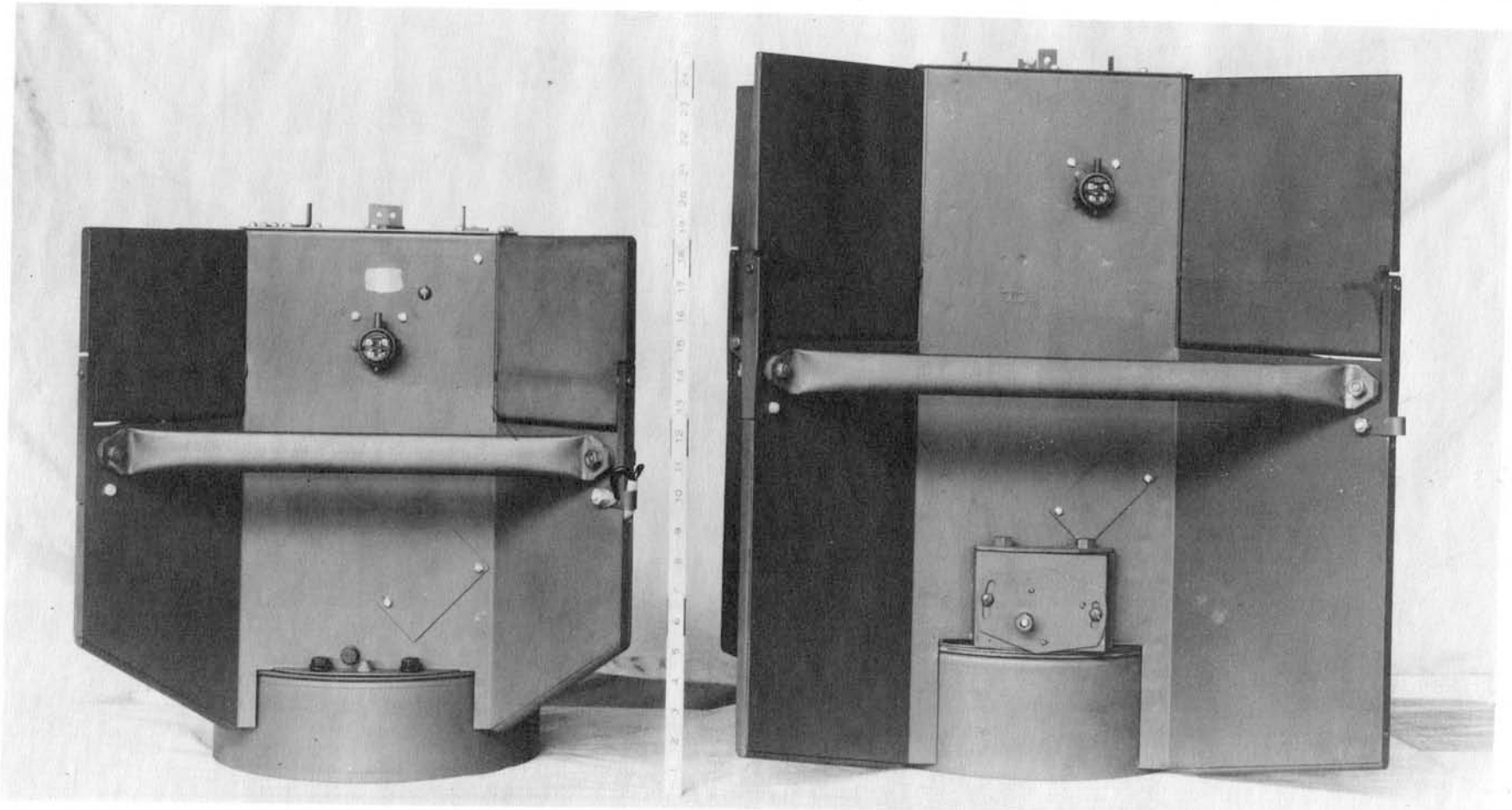


A Z - 1 A Z - 2

View Showing Difference in Size and Outer Construction

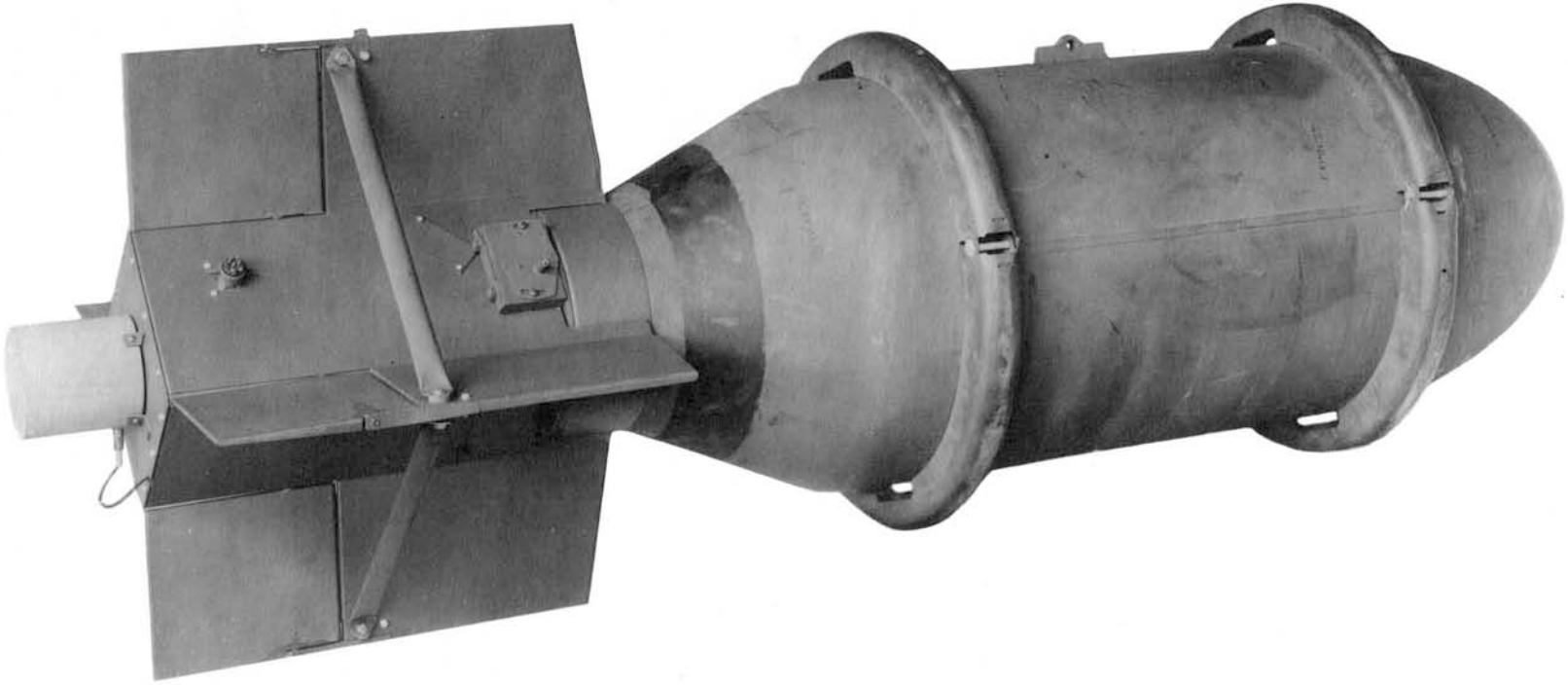
The item known as the AZ-2 -- or tail assembly for high-angle dirigible bombs of 2,000-pounds weight -- was produced in the amount of 132 units for test purposes by The Union Switch & Signal Company, during the year 1944. Of the number produced, 131 were shipped to various stations of the Army Air Forces, while one unit was retained by the Company at its plant at Swissvale, Pa., for engineering and reference purposes.

While it was reported to the Company that all tests of the AZ-2 proved to be eminently satisfactory, the item never was placed in quantity production because of the diminished military need for such a bomb.

In all essentials the AZ-2 is but an amplified counterpart of the AZ-1 -- (described in Pages 241 - 258 of this report). The chief differences are in size and weight of the assembled unit, together with the use of some additional, and some larger, parts, made necessary because of the increased weight of the bomb to which it is attached.

(Full details as to engineering development, size of parts)
(and method of assembly, are contained in reports of the)
(Company's special Research and Engineering Department.)

It was early in 1944 that the Company -- which as related had successfully worked out the final development of, and procedure for quantity production of the "Azon" or AZ-1 -- was asked by the National Defense Research Committee of the Office of Scientific Research and



AZ-2, With Flare at Rear, Attached to Bomb

Development, to do the same job on an Azon device for a 2,000-lb. bomb. On February 17, 1944, the Company received an order for construction of a test unit. This was assigned the Company designation of GO 515850 -- OEMsr-1285. In March, the quantity asked for was increased to a total of 100, and a little later on an additional 32 were ordered.

- - -

The first shipment of the AZ-2 was made to an Army Air Forces test station on June 25, 1944. Additional shipments were made in July, September, October and November. The last 31 units of the order were shipped on January 5, 1945, one being retained -- by agreement -- at the Company's plant.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

DEVELOPMENT AND PRODUCTION

OF

THE VB-3 ("Razon")

--o--

End of War in August, 1945, Found Company Busy on Production of Units for Army's Air Forces -- Original Work on Engineering for Production of one of World War II's "Secret Weapons" Ordered by National Defense Research Committee -- Company, the Sole Producer in the United States, Made Many Changes in Design of Experimental Units, Increasing Efficiency of Item and Ease of Production

--o--

The task of engineering for production, of the tooling and of the production of 150 units of the VB-3, or "Razon", one of the "secret weapons" used by the Army Air Forces of the United States, was entrusted to The Union Switch & Signal Company during the latter part of 1944 by the National Defense Research Committee of the Office of Scientific Research and Development. This device -- a tail attachment for an airplane bomb of 1,000-pounds weight, to make it dirigible both in azimuth and rangé -- operates under the same general principles governing the operation of two earlier dirigible bombs -- the AZ-1 and AZ-2.

(Reports on these two latter devices are found in Pages 241 to 258, and 259 to 261, of this report, while extensive engineering and assembly data is to be found in reports in the files of the Company's Research and Experimental Engineering Department. It is not included in this report because of the secrecy surrounding the VB-3.)

- - -

Because the VB-3 is dirigible -- or capable of being controlled while in flight, or fall -- both in range and in azimuth, the device was better known as the "Razon." The earlier devices -- AZ-1 and AZ-2, being controllable in azimuth only, received their designation of "Azon" from that fact.

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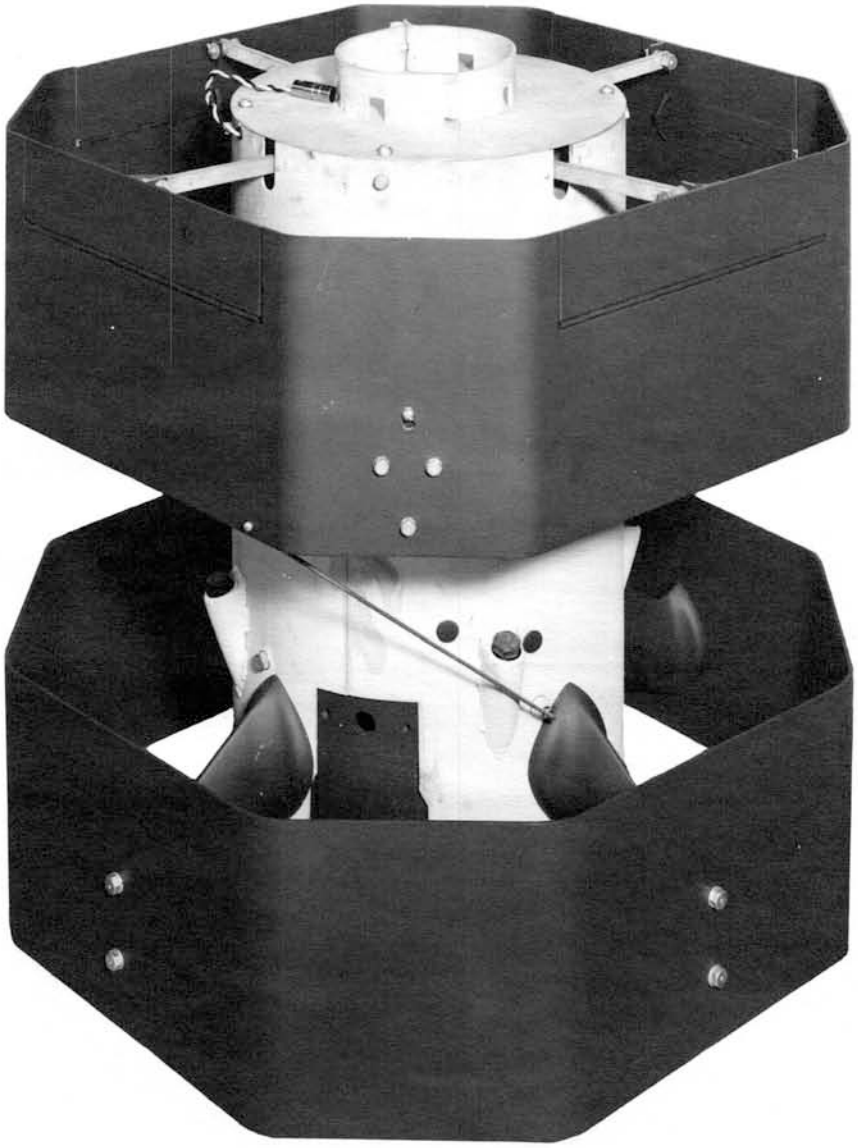


VB-3, Fully Assembled

Ready for Attaching
to Bomb

The VB-3 was developed by the Company, and engineered for production, from experimental models designed and constructed by the Gulf Research and Development Company. Many changes in design were necessitated -- some as the result of experience in the field, some because of manufacturing requirements, while some were made because of requirements imposed by the Army Air Forces and by the Aircraft Radio Laboratory at Wright Field, Ohio.

- - -

Even before the Company had fully completed production of the first 150 units under its contract from the NDRC/OSRD, it was authorized by that group to proceed with the quantity production of 1,000 units for the Army Air Forces. This was on December 6, 1944. In April, 1945, the Army Air Forces increased the contract to 3,000 units and, on June 6, 1945, still further increased the order so that it called for 23,000 units.

With the capitulation of Japan, and the end of the war in August, 1945, the order was cut back by 20,000 units to the previous total of 3,000, and there was a possibility that the entire order would be closed out in the number shipped to date. However no definite decision was made on this point and the Company continued to produce and ship. Up to October 31, 1945, a total of 978 units had been forwarded, and the Company still was in production.

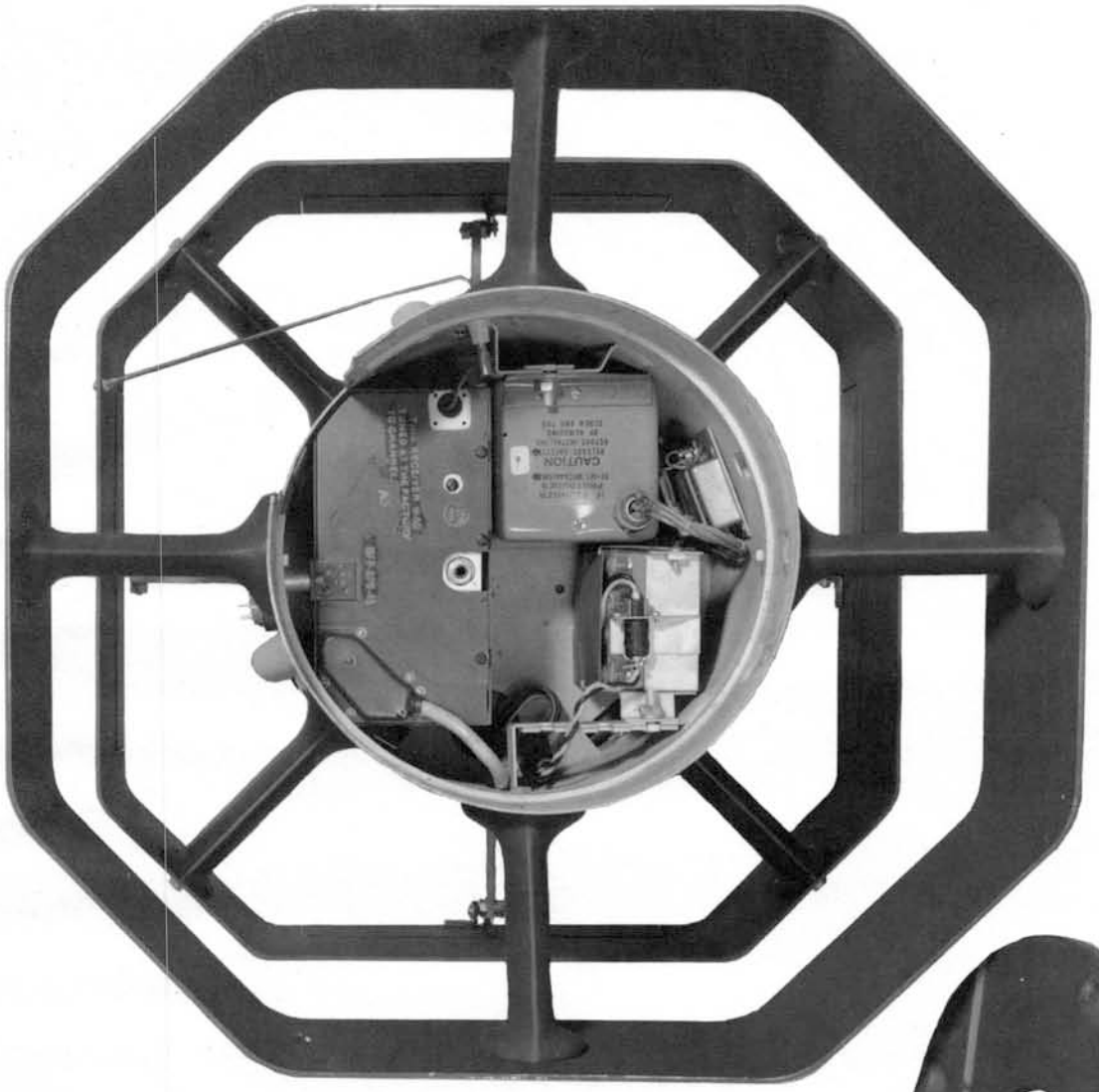
The first shipment of the VB-3 units under the foregoing order -- (AAF Contract W-33-038-AC-10322 -- US&S GO 531800) -- was made in the number of ten units on August 10, 1945. This was followed by another 20 units on August 14, and another 50 units on August 28.

* * *

It was on October 1, 1944, that the Office of Scientific Research and Development instructed the Company to proceed with the work of engineering development on the VB-3, and the construction of 150 units for field tests. The first inquiries on this had been made in June of that year. The Company signified its acceptance of the order -- including tools -- on October 26. The first 24 units were shipped out on April 30, 1945. Another 32 units were sent out in May; another 51 in June and 39 more in July, one unit being retained at the Company's plant in Swissvale -- under agreement -- for engineering and production reference. Six final test panels also were constructed under this OSRD order -- (known as OEMsr-1415 -- US&S GO 530250) -- of which two were shipped, the other four being held at the Company's plant awaiting shipping instructions.

* * *

For an explanation of the general functioning of the VB-3, reference is made to the report on the "Azon", or AZ-1 -- (Pages 241-258 of this report) -- bearing in mind that the VB-3 is controllable in azimuth (sidewise) as well as in range. Consequently the VB-3 has more moving



View of VB-3 Showing Sleeve
and Cover by Which Device
is Attached to Bomb

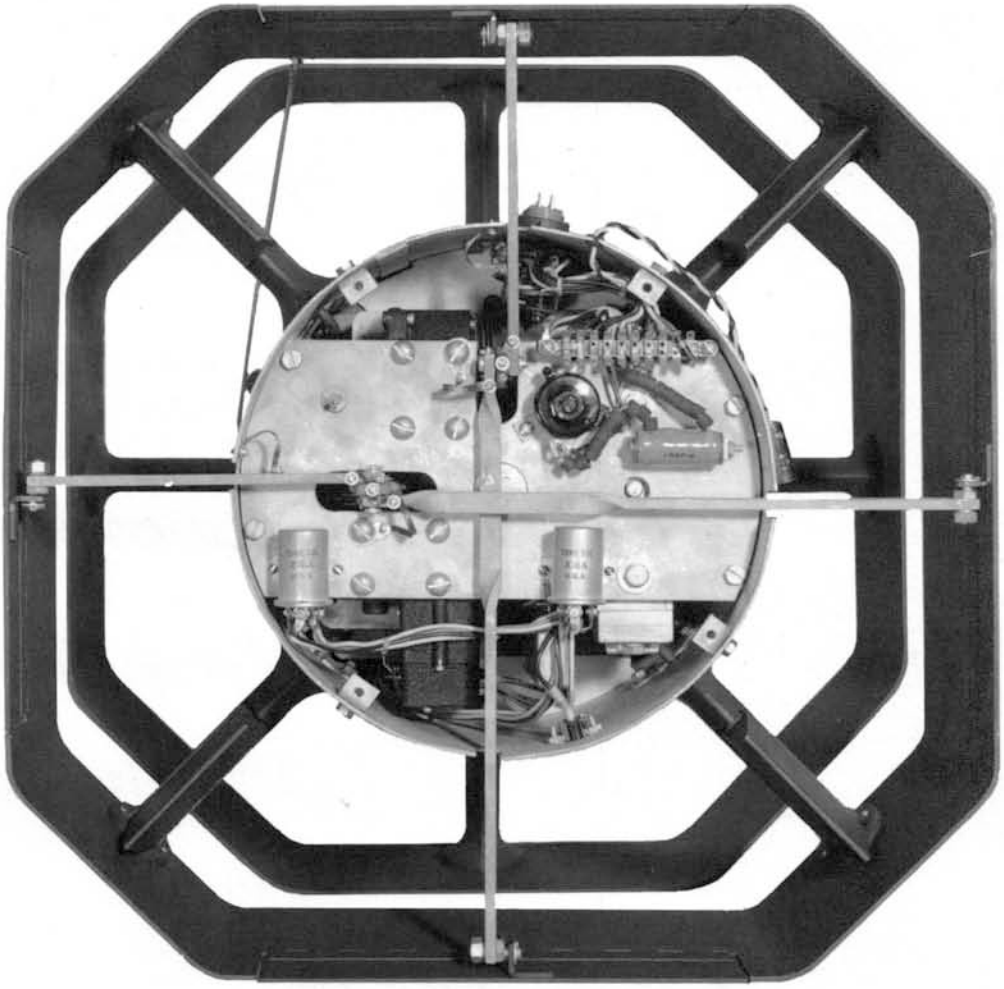
parts, and additional elements enter into its assembly and construction. Among the additional parts are four flaps, or ailerons, located inside the shroud, and controlled by the gyroscope through solenoids; two flaps, or horizontal elevators, located on the edge of the shroud and controlling the vertical fall -- or range -- of the bomb. There also are two rudders, also located on the edge of the shroud, which control the azimuth, or deflection of the bomb in fall. Servo motors control the elevators and rudders. The impulses actuating the Servo motors are transmitted by radio receivers carried in the unit, these receivers receiving signals from a transmitter located in the bombing plane, and sent out by the bombardier.

- - -

In its work of development for production purposes, the Company based its work largely on the design and experimental units made by the Gulf Research and Development Company, under its development contract with the NDRC/OSRD. A number of changes were necessitated. Amont those made by the Company were:-

1) The outside diameter of the cylinder housing the apparatus was increased by a quarter of an inch, the diameter of the experimental unit being too small to provide the necessary manufacturing tolerances.

2) The speed of the terminal shaft transmitting power from the Servo motors was changed from 4 rpm to $2\frac{1}{2}$ rpm.



Rear View of VB-3

Showing Some of the Controlling Mechanism; Rear Cover and Flare Clamp at Left

3) The "kick-off" plug was changed from 6 to 4 prongs.

4) A new type battery -- the ER-4-6 -- was substituted for the two NT-6 batteries used in the first designs. Of the same overall dimensions as the NT-6, the ER-4-6 was found to have sufficient capacity to take care of the requirements of the VB-3 and, in addition, it had a special filler plug to make it more convenient to use and service in the field.

5) The size of the control flaps was slightly reduced and the control rod was moved slightly so as to attach it 2¼" from the centerline of the hinge.

6) It being found necessary to use a lift shroud in addition to the control shroud, a more practical method of attaching the tail to the bomb was devised. This consisted of using four bolts inserted at an angle, instead of a greater number of bolts inserted radially.

7) The position of the control shroud also was changed to make the trailing edge flush with the trailing edge of the cylinder.

8) A new radio -- developed under the supervision of the Aircraft Radio Laboratory -- was used in connection with the VB-3. This required the installation of 12 noise filters, and it was necessary to change the wiring on the unit to install these filters.

9) At the request of the Special Weapons Division of the Army Air Forces, located at Wright Field, a new method of clamping the flare on the unit was devised. This was to do away with the necessity for extra clearance in order to attach or remove the flare when the bomb was in the bomb bay of the plane. Also, a device which would make attachment and removal more convenient was desired. The results sought were obtained by clamping the flare between two straps. One of the straps was hinged and could be turned out of the way, then brought back and bolted to the other strap when the flare was in place. This new type of clamp for the flare was disclosed as an invention -- by the Company -- after reports had indicated that it was "very practical."

Other changes included one for charging the battery. This was necessitated because of the greater capacity of the new type of battery. A separate socket, into which a plug could be inserted to test

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

the battery, and through which the battery could be charged from a separate source if necessary, was added.

Many changes in details of design were made in order to adapt the parts for production, as well as for ease of assembly. When it was found that additional bonding was needed so that the noise filters could be made effective, it was decided to tin-plate everything included in the ground circuits. These filters were added to eliminate the high frequency noise from the Servo motors and the gyros. The plating involved not only the small parts but the cylinder itself, and the gyros and motors also had to be modified to make good ground connections with the rest of the apparatus.

* * *

As in the case of production of the AZ-1, and the development of the AZ-2, a special department was set up for the development and production of the VB-3. In order to accommodate the necessary production line, machines, additional help, etc., called for by the order for 23,000 VB-3s, construction of a new one-story building was commenced on a portion of the Company grounds, this being erected by the Company without any cost to the Government. It was intended to house the special department and -- because the work on the VB-3 was "secret and confidential" -- to isolate it from other buildings. The end of the war came before the building was completed, and it will be used by the Company for other purposes.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

20 MM. A. P. - (Solid) - SHOT - M95

--o--

Company Engaged in Production on Order for 1,550,000 of Item When Japan Capitulated -- Total of 312,300 Shipped Before Contract Cancelled -- Use Made of Same Department and Machines That Produced 20 MM. H. E. Shell

--o--

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

When Japan signified its capitulation to the United Nations on August 14, 1945, The Union Switch & Signal Company was engaged in producing the item known as the 20 MM. A. P. - (Solid) - Shot M95, and was building up production so that some half-million pieces a month could be shipped each month. The contract on which the Company was engaged, called for a total of 1,550,000 pieces. At the same time the Company had a back-log in an order calling for an additional 2,550,214 shot with shipments to run through April, 1946. This order, however, was cancelled complete, under date of August 15, 1945.

- - -

The first order -- for 1,550,000 shot -- was closed out in the amount of 312,300 pieces, the final shipment being made August 24.

- - -

It was while the Company was still engaged in production of the 20 MM. H. E. Shell -- (see Pages 75 - 91 of this report) -- that it received the first inquiries regarding production of the solid, or armor-piercing projectile. This was on January 6, 1945. Four days later the Company was informed that its production of the 20 MM. High Explosive Shell would be discontinued about April 1, so that production of the 20 MM. A. P. Shot could be started. On January 28, the Company was notified it had been awarded a contract for 2,075,000 of the latter item. The Company accepted the contract on February 8.

(As related in the section of this report dealing with the production of the 20 MM. H. E. Shell, the changeover in production was scheduled to take place in April, 1945. Immediately upon conclusion of production under US&S GO 512150 -- which was closed out at the figure of 9,500,000 of the 20 MM. H. E. Shell -- the Company began to tool up and convert its department for production of the Armor Piercing projectile.)

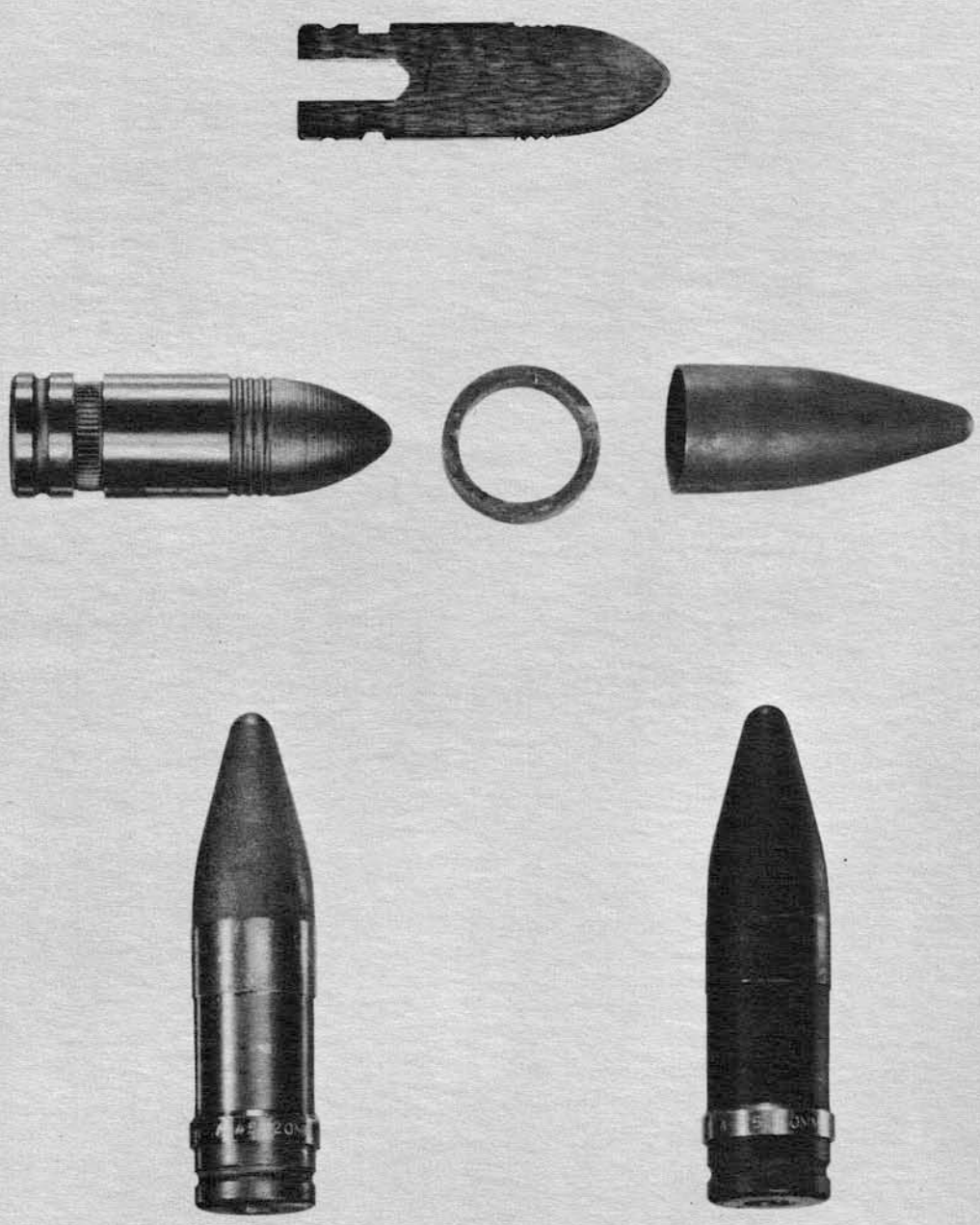
- - -

The first shipment of the A. P. Shot was in the amount of 18 pieces. These were test pieces and went forward on May 29, being sent to a Government proving grounds. The first quantity shipment was made July 16, 1945, in the amount of 83,100 pieces, these being forwarded to the Kingsbury Ordnance Plant, Kingsbury, Indiana. This shipment was followed by one of 99,000 pieces on July 31, with a third -- of 79,200 pieces -- on August 10. A total of 1,087 pieces in all also were shipped to Government proving grounds at test pieces.

- - -

Even before the Company began its production on the first order, it received notification that the amount of 2,075,000 pieces called for probably would be cut back. This was on March 17. On May 26, word was received that the contract would be cut back to a total of 1,550,000 pieces.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY



20 MM. ARMOR PIERCING SHOT-M95

The schedule of shipment set up when the notice of the cut-back was received, called for the first shipment to be made in May, in the amount of 50,000 pieces. This amount was doubled for June while, beginning in July and running through January, 1946, shipments were to be in the amount of 200,000 pieces each month.

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In July the Company was notified that the schedule would have to be revised and that while the Company was producing at the rate of 200,000 a month, it would have to step up production to 500,000 a month. The schedule of 200,000 a month would hold for July and August, but it would be increased to 300,000 in September and October, and must reach 500,000 a month by November. It was when the Company was reaching this rate of production that the contract was cancelled.

- - -

Two days before this revised schedule was presented, the Company was asked to submit bids on production of 2,550,214 additional shot. The bid was submitted and the Company was notified -- on August 6 -- that it had been awarded the Contract. Shipments would begin in November and run through April, 1946. This contract was terminated in entirety on August 15, 1945, when the first contract also was closed out in the amount of pieces shipped and in the bond room.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

In addition some 544,000 shot were in process when the notice of cancellation was received. A total of 261,300 pieces had been shipped up to August 15, and there were 51,000 pieces in the bond room, so that the contract was closed out -- with a final shipment on August 24 -- in the amount of 312,300 pieces. Negotiations were conducted with a view to adjustment for the work in process.

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945

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REMARKS ON MANUFACTURE AND PRODUCTION:

First operations on the Solid Shot were -- in many respects -- the same as those performed on the High Explosive Shell. However, since the shot was solid the nose was not bored. Instead a Tracer Hole -- which carried a critical angle at the bottom -- was drilled in the base of the shot.

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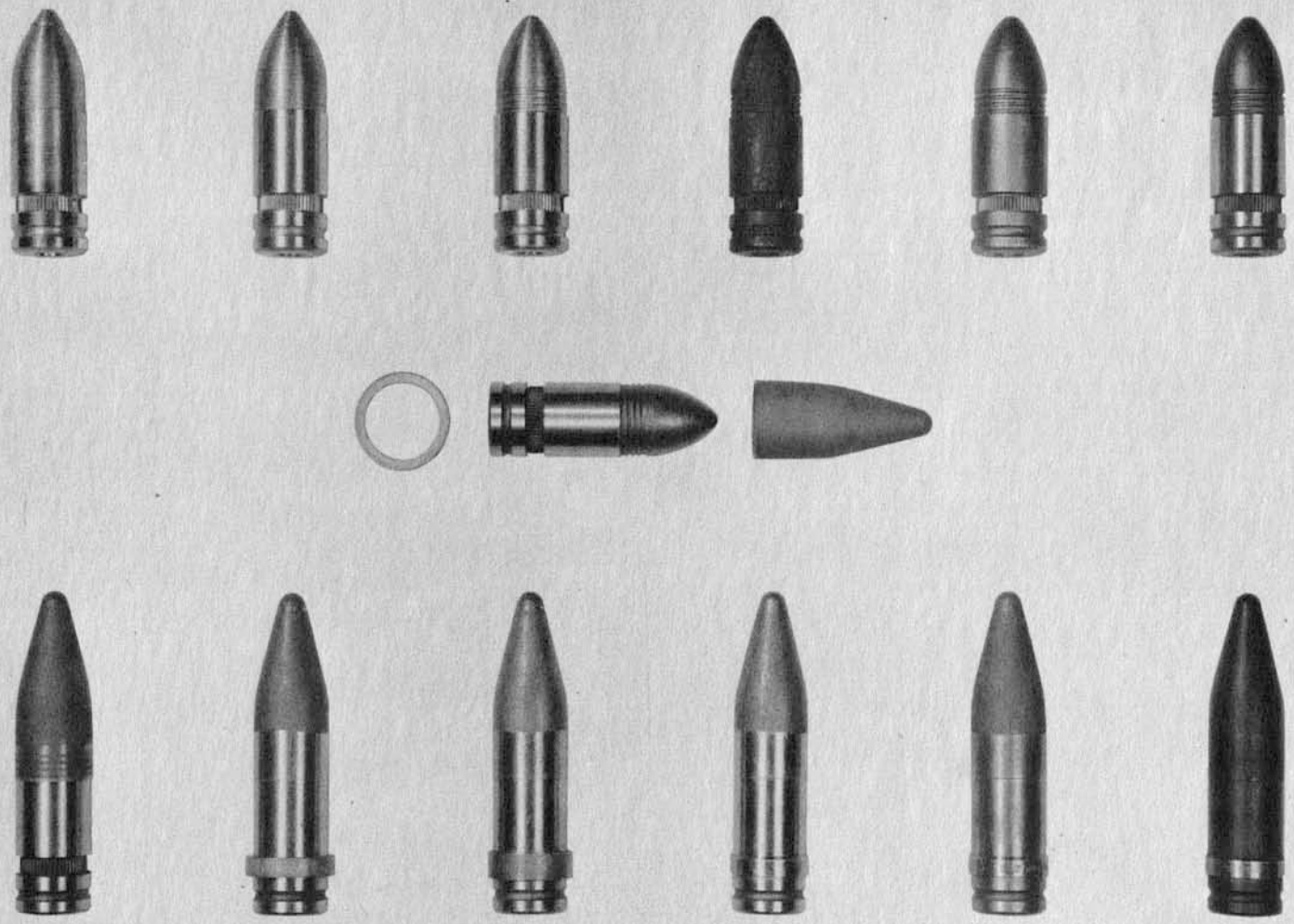
The automatic screw machine operations on the shot were checked through 8-hour shifts, 24 hours a day, by the machine operators and a roving inspector, a complete set of gages covering all automatic tolerances being placed at each machine. The exact sequence of operations on the shot ran as follows:-



IMPORTANT STEPS IN THE PRODUCTION OF 20 MM. ARMOR PIERCING SHOT-M95

Turn, form, drill and cut off; grind base end; form nose, groove for windshield and size for length and weight; heat-treat all over -- (the heat treatment was most critical); draw; roto blast; grind outside diameter to finish dimensions; Magnaflux; assemble windshield after latter was burred; trim -- finish back edge -- of windshield; assemble rotating band, swage and machine; degrease, paint, stamp, final inspect, box for shipment.

- - -

All dimensions were inspected 100%, and the piece in process also was constantly being checked by operators and inspectors, the necessary ring and snap gages being provided at all machines. The heat treatment also was carefully checked, while on the Magnaflux machine, the shot was checked 100% for seams and cracks. All snap and adjustable gages were checked by use of master gages at least once each shift. All other gages were given visual check daily and changed or corrected as required.

- - -

The windshield and the rotating band -- both purchased items -- were pressure squeezed and swaged. The outside of the shot was painted black, with the exception of the rotating band, a lusterless black paint being used. The tracer hole in the base of the shot was painted with a dark brown paint.

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

As previously stated use was made of the same department and machines for producing the 20 MM. A. P. Shot, as had been used for the production of the 20 MM. H. E. Shell.

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In the matter of personnel -- as of August 1, 1945 -- at peak production, a total of 23 women and five men were used for inspection, a triple-turn, seven-day week being worked. In production -- with women being used in all piece-work operations -- there was a total of 40 women and 43 men, working a triple-turn, seven-day week.

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PRODUCTION
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SIGNAL COMPANY

PRODUCTION
OF
WAR MATERIEL
1940 - 1945

THE
UNION SWITCH
&
SIGNAL COMPANY

MACHINING OF PARTS FOR "T-1" AIR COMPRESSOR

(On orders from Westinghouse Air Brake Co.)

--o--

Total of 347,345 Pieces Produced and Shipped by Company in Eight-months Period -- Parts Used in Assembly of Tire Pump Contracted for by Pittsburgh Ordnance District and Adopted by U. S. Army as Standard

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In connection with its production of items of war materiel, The Union Switch & Signal Company, as sub-contractor, machined and shipped to the Westinghouse Air Brake Company, a number of parts used in the assembly of the "T-1" Air Compressor, or Tire Pump. This was being produced by the Westinghouse Air Brake Company under contracts from the Pittsburgh Ordnance District. These pumps -- which were attached to the engine blocks of Army jeeps and trucks -- had been adopted as standard by the United States Army in 1943.

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In the period between November 20, 1944, and July 5, 1945, a total of 347,345 pieces was shipped by the Company to the prime contractor. These parts ranged from Cap Nuts to Generator Pulleys. A table showing the number of pieces of each item produced and shipped by the Company, is to be found at the end of this report.

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The first order -- T-182 -- was received by the Company on October 27, 1944. This was for the machining of 800 Generator Pulleys, the rough castings of which were furnished by the Westinghouse Air Brake Company. These machined pulleys were to be shipped at the rate of 150 daily. On December 6, the number of pulleys was increased to 1,200. The first shipment -- of 20 pieces -- was made on November 20. The or-

der was not completed in entirety however, being closed out in the amount of 965 pieces on January 6, 1945, on which date 171 pieces were forwarded.

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A second order -- later cancelled in entirety before any of the items were produced -- was received on October 31, calling for the machining of 6,000 Piston Followers. The cancellation of the order was received on November 13.

- - -

The third order -- T-209 -- for 10,000 Cap Nuts, to be machined from 1 1/8" hex cold rolled steel, was received November 7, 1944. The first shipment -- in the amount of 871 pieces -- was made November 27. The order was completed in entirety, with a shipment of 734 pieces on January 27, 1945.

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Order No. T-252, received November 17, 1944, called for the production of from 10,000 to 20,000 each, of eight items. The table on the next pages shows the quantities ordered, the name of the part, and amounts shipped:-

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

Amount of Order	Name of Part	Total Number Shipped
20,000	Cap Nuts	19,781
20,000	Piston Follower	19,443
10,000	Piston, Bushed	9,591
10,000	Clutch Pin	9,615
10,000	Latch	9,541
10,000	Spacer	10,000
10,000	Latch Pivot Pin	10,000
10,000	Clutch Pin Plug	10,000
100,000 --	T o t a l s --	97,971

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The last shipment of any of the items on the above order was made on February 26, 1945.

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A series of orders were received on January 18, 1945. These are listed in the table below:-

Order Number	Name of Part	Amount Ordered	Amount Shipped	Shipments Made Between:
T-316	Cap Nut	30,000	32,760	2-15 and 2-28-45
T-317	Piston, Bushed	16,000	15,626	2-27 and 5-22-45
T-318	Piston Follower	32,000	32,000	2-23 and 5-30-45
T-319	Clutch Pin	16,000	16,000	2-26 and 5-19-45
T-320	Clutch Pin Plug	16,000	16,000	Complete on 2-26-45
T-321	Latch	16,000	16,000	2-17 and 5-9-45
T-322	Latch Pivot Pin	16,000	16,410	3-7 and 3-15-45
T-323	Spacer	31,000	31,000	3-10 and 3-26-45
	T o t a l s:	173,000	175,796	

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The next order — T-366 -- was received on April 24, 1945. This was for 2,000 Generator Pulleys. The first shipment -- of 33 pieces -- was made May 24. The order was closed out in the amount of 1,434 of the items on July 5, 1945.

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On May 1, 1945, Order No. T-373 was received. This called for a number of parts, none of which were produced in the amounts ordered. The list below shows the parts ordered and number shipped. The final shipment of any of the items was made on June 20, 1945:-

Amount Ordered	Name of Part	Closed Out At:
20,000	Cap Nut	5,846
10,000	Clutch Pin Plug	(Cancelled in entirety)
16,500	Clutch Pin	6,831
16,500	Latch	5,803
16,500	Latch Pivot Pin	13,500
13,500	Piston, Bushed	8,526
18,000	Spacer	14,000
33,000	Piston Follower	6,673
144,000	-- T o t a l s ---	61,179

* * *

PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

The total number of pieces of each item, together with its part number -- (in parentheses) -- and the material from which it was machined, is given in the table below:-

Number Shipped	Name of Part and Piece Number	Made From:
68,387	Cap Nut - (185902)	1 1/8" hex cold rolled steel
33,743	Piston, Bushed - (185903) Bushing - (185905)	Iron casting -- and- 7/8" round cold rolled steel
58,116	Piston Follower - (185906)	1 13/16" round cold rolled steel
32,446	Clutch Pin - (185919)	13/16" round cold rolled steel
26,000	Clutch Pin Plug - (185920)	9/16" round cold rolled steel
31,344	Latch - (185925)	Brass casting
39,910	Latch Pivot Pin - (185928)	9/16" round cold rolled steel
55,000	Spacer - (185946)	3/8" round cold rolled steel
2,399	Generator Pulley - (186000)	Rough iron casting
347,345 --	Total pieces shipped	

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY

INDUCTIVE HEATING WINDINGS AND PARTS

and assembly into containers
used on presses for

EXTRUSION OF DURALUMIN PARTS

--o--

Manufacturing Procedure Pioneered by Company for Schloemann Engineering Corporation, Manufacturers of Giant Extrusion Presses -- Only Company in United States Producing Such Units -- Company Also Developed First Practical Type of Electrical Joint and Terminal Laminations

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A little more than five years before the United States entered World War II, The Union Switch & Signal Company had instituted the technique of manufacturing and assembling heating windings into heating units used to maintain the temperature of billets for the extrusion die process of manufacturing duralumin forms. Such forms are in heavy demand by the airplane industry. The patents on the windings and units are held by the Schloemann Engineering Corporation, Pittsburgh, Pa., manufacturers of the giant extrusion presses on which the heating units are used.

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Huge containers, through which are placed copper rods, which in turn are connected to sources of alternating current, are fitted into the extrusion presses manufactured by the Schloemann Corporation. The containers -- machined from steel forgings and weighing anywhere from three to fourteen tons -- are placed ahead of the die. Pre-heated billets are loaded into the bore of the heating container, the current is passed through the heating windings -- (the copper rods which are covered with asbestos insulation) -- and, by induction, the temperature of the billet is maintained, or increased to a pre-determined degree. Hydraulic pressure is exerted and the softened metal is forced through the die into the desired shape. This shape is determined by the die.

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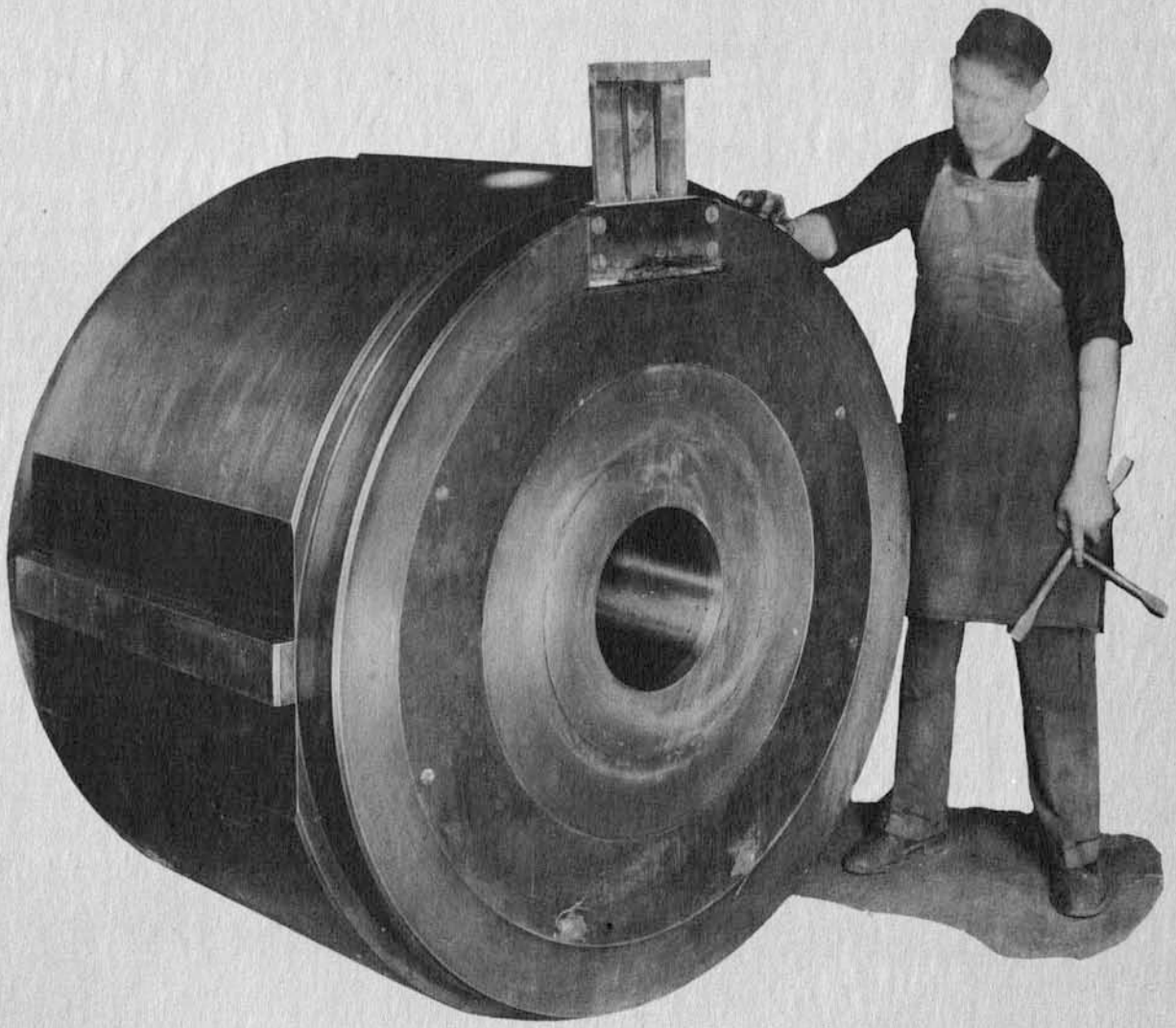

14-TON INDUCTIVE HEATING UNIT
FOR 5200-TON EXTRUSION PRESS

The Union Switch & Signal Company is the only company in the United States manufacturing and assembling the heating windings for the Schloemann Corporation, and for the years from 1936 to 1941 -- as well as during the war years since -- have assembled the complete container, or furnished parts for heating units, for the various plants of the Aluminum Company of America. During the war years, on several occasions, a number of assembled containers were shipped to Canadian plants of the Aluminum Company.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

(Under Lend-Lease orders received by the Company on October 6, 1944, four assembled containers -- to be used on 5,000-ton extrusion presses -- were shipped by the Company to Russia, the order having been placed on behalf of the Soviet Purchasing Commission in the United States. Each of the containers weighed 24,000 pounds. The shipments went forward in April, 1945. Also, under date of May 2, 1945, a fifth heating winding and assembly for use on a 5,000-ton extrusion press, was shipped to Russia, the shipment being made under date of July 15, 1945, on orders from the United States Treasury Department, Procurement Division.)

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It was on October 29, 1936, that the Company, after the suggestion that inductive heating be used to maintain the temperature of the billets had been advanced -- received a request from the Schloemann

Corporation for an estimate on the manufacture and assembly into containers of the necessary heating parts. The Company really began production on a large scale with its first order for six sets of the windings. This order was received May 25, 1937, the final shipment on the order going forward on February 22, 1938.

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Between that date, and what might be termed the first order for containers, the end-use of which was the manufacture of items to be used in war materiel, the Company made the parts for, and assembled the parts into some 63 containers, in addition to filling numerous orders for parts.

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The first big, war-demanded, order was received by the Company on November 25, 1940. This was for 24 containers to be used on 2,500-ton presses. The first shipment of the containers was made on April 30, 1941, the last on October 13, 1941. Following this some smaller orders were received. Then -- on May 5, 1942 -- inquiries were received for production of assembled containers for use on presses of from 1,600- to 4,250-ton presses. Quotations went forward on May 14, and the first order -- for 10 containers to be used on 1,600-ton presses -- was received on May 18, 1942. Shipment of these containers was made between April 15, and August 10, 1943.

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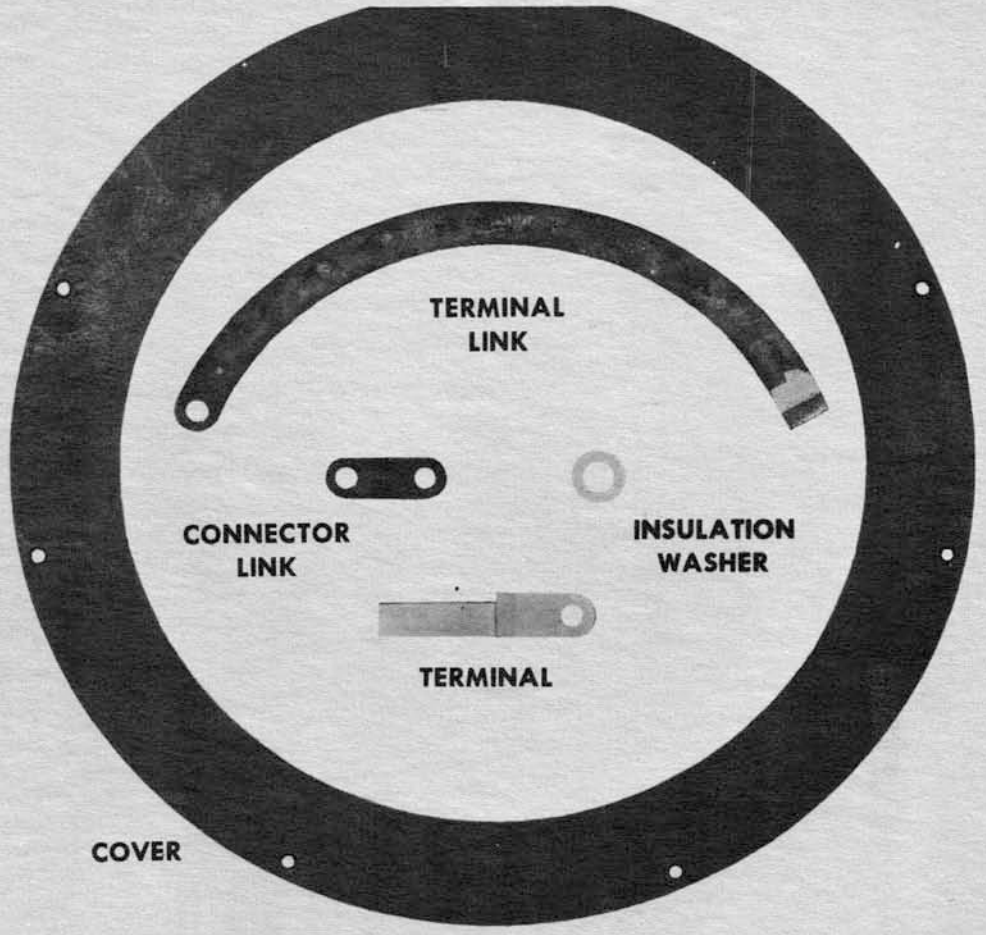

COPPER ROD—CALORIZED AND ASBESTOS WOUND

COPPER ROD—CALORIZED

COVER AND COIL ELEMENT PARTS
FOR EXTRUSION PRESS INDUCTIVE HEATING UNIT

Based on the same quotations, another order -- this for 40 containers to be used on 2,500-ton presses -- was received the same day. These were to be shipped at intervals between April 5, 1943, and August 8, 1944. A third order -- for 28 containers for use on 4,000-ton presses -- was filled between May 3, 1943, and February 1, 1944.

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On January 6, 1943, two orders -- for a total of four containers to be used on 2,500-ton presses -- were received. The shipments on these orders were made between November 8, 1943, and February 25, 1944.

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The Canadian shipments were of two 2,000-ton press containers; two 2,500-ton press containers, and four 5,000-ton press containers. The orders covering these were received April 4, August 2, and August 12, 1943, respectively. The shipments went forward between June 30, 1943, and March 31, 1944.

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Additional orders for a total of 18 containers to be used on various size presses, were received between March 9, 1943, and January 13, 1944. A number of orders for spare parts -- in various amounts -- also were received in 1943, 1944 and 1945, all being filled.

* * *

GENERAL REMARKS ON PRODUCTION OF HEATING UNITS:

The services of five different departments enter into the work done on the heating windings and their assembly into units. Some 21 individual parts for the containers are manufactured in these departments. In addition there is the final assembly department. Use is made of the facilities of the Company such as a boring mill, lathes, drills, the forge shop, the plating department, silver soldering and milling.

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PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

The containers, forged from steel, varied in weight. The smaller containers were machined by the Westinghouse Air Brake Company from forgings sent to it. The larger containers are forged and machined by the Erie Forge Company, Erie, Pa., and sent directly to the Company's plant.

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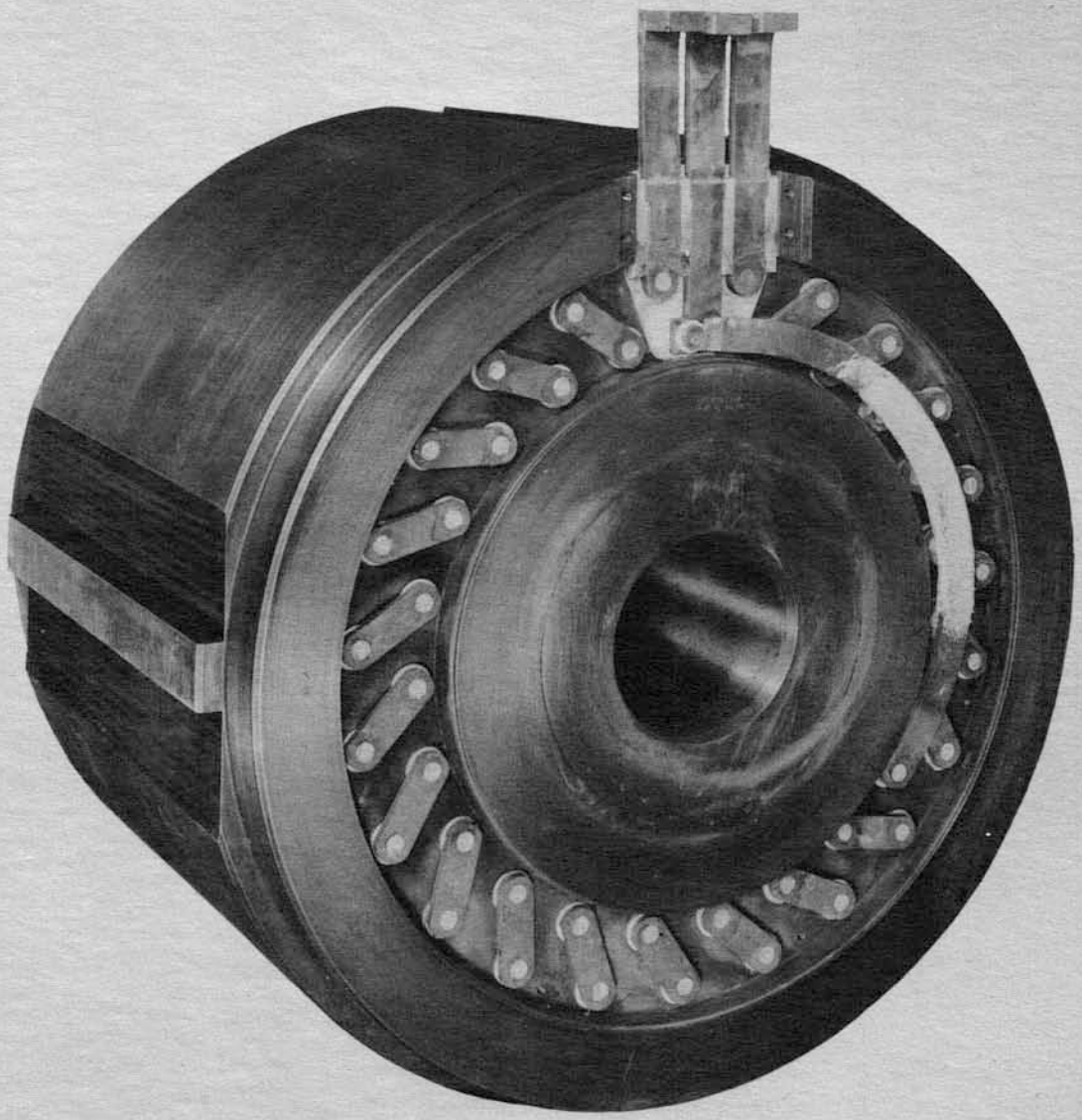
Some 202 individual parts enter into the assembly of each container. These parts are:- (1) front cover; (2) rear cover; (3) insulation cover for terminals; (4) 39 winding rods; (5) 36 connecting links; (6) two terminals; (7) terminal connector; (8) phase connector; (9) 88 insulating washers; (10) two stainless steel collars; (11) 14 countersink-head screws; (12) top and bottom half-clamps; (13) two clamping screws for insulating cover; (14) locking screw and locking plate for locating



INDUCTIVE HEATING UNIT
WITH COVER REMOVED TO SHOW COIL CONNECTIONS

phase connector; (15) three insulating collars; (16) top and bottom transite asbestos wood plates for terminals; (17) asbestos shielding for phase connectors and terminal bars; (18) connector laminations; (19) connector terminal block; (20) terminal cover for mounting on press, and, (21) terminal cover guides for mounting on press.

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In assembling the heating container, four major operations are performed:-

(1) Silver solder two copper rods and their connectors assembling unit into container -- (there are 16 sets of rods to each container); (2) turn over container and assemble connecting links, terminals and terminal connectors to opposite side; (3) assemble cover to front side; (4) set container on side, and attach phase connector to first side and assemble cover.

PRODUCTION OF WAR MATERIEL 1940 - 1945

THE UNION SWITCH & SIGNAL COMPANY

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Failure at the electrical joints was reported in the case of the first container assembled. The Company then engineered and developed a new type of joint, and also a new type oflamination used in the terminals. The system since that time has functioned with 100% success.

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As with most of its other production of war materials, the Company made use of its existing facilities -- plant and machines -- to manufacture the parts for, and assemble these heating containers, without the purchase of new equipment other than replacement of worn-out tools and equipment.

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Every production schedule over which the Company had any control was met. It will be noted in the first part of this report there often were long lapses of time between the receipt of an order and the date of the final shipment completing the order. This time-lag was due to at least two causes, in each instance. First, non-receipt of the machined containers into which the heating units were to be assembled, and, second, holding-up of shipments on orders from the prime contractor or the purchaser of the equipment. Very often the equipment had been ordered before the purchaser had the available space in which to locate it, hence the container, or the parts, were held at the Company's plant awaiting shipping instructions.

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Several orders received by the Company for assemblies of the heating units later were cancelled due to changes in the Government's requirements as to locations of plants. Cancellation charges and adjustments were entered and made in such cases.

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PRODUCTION OF WAR MATERIEL 1940 - 1945
THE UNION SWITCH & SIGNAL COMPANY